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ANNUAL REPORT

CALIFORNIA FOREST AND RANGE EXPERIMENT STATION

M.W. Talbot, Acting Director—Berkeley, California

1941



FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE
Southwestern Forest & Range Exp. Sta.
TUCSON, ARIZONA
APR 4 1942
RECEIVED

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January 1942

ANNUAL REPORT OF THE

CALIFORNIA FOREST AND RANGE EXPERIMENT STATION^{1/}

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FOREST RESEARCH IN WARTIME

Research looks at a changed and changing world. New curtailments. New demands. New needs. New challenges. A new tomorrow.

For Research itself, at the moment, these opposing forces mean new appraisals, orientation, planning, efficiency. An unfortunate combination of circumstances intensifies the difficulty Research faces in attempting to continue to function effectively. CCC and other emergency programs, on which Research has depended for much essential assistance, have dwindled or vanished at the time of greatest war pressures. All possible means of meeting this situation should, of course, be carefully considered. Such possibilities include (1) dropping some studies of low priority, (2) discontinuing a few others "for the duration," (3) curtailing some to the level of minimum maintenance, (4) reorienting others in line with war needs, and (5) undertaking no new work — except urgent war projects. After making the most of these possibilities, however, there still remain highly important studies and experiments which cannot be changed radically without heavy loss. The dilemma in which Research finds itself, therefore, resolves down to a two-fold task:

1. To redirect programs as fully and as effectively as possible toward wartime requirements.
2. To keep going the most important projects representing the heaviest investments and possessing the highest promise of good dividends.

The first task needs no elaboration. It is an obvious duty and a patriotic privilege. On this point our personnel may be depended upon for "all-out" cooperation.

The second task is a serious challenge, a cause of much concern. and a problem not yet solved. Curtailment of "low priority" or "non-defense" research projects is one thing. Sound definitions of such terms and recognition of such projects is quite another matter. Actually, during the war period, the need for tested facts is increased rather

^{1/} Maintained by the U. S. Department of Agriculture at Berkeley, Calif., in cooperation with the University of California.

than diminished. Production stimulated by war makes more difficult the safeguarding of basic land resources. Costly land-use mistakes, such as wasteful cutting of high-quality timber and overgrazing of ranges, which occurred during the last World War, are easily made. More heavily than at other times Research shares the responsibility of lessening the inevitable impact of war on our forests, watersheds and range lands. One way to meet this latter obligation, in part — but only in part — is to speed up the assembly line of research reports. We are committed to strenuous efforts toward this end.

Of equal or possibly greater significance is the certainty that curtailment of really essential research during the war emergency weakens just that much the factual foundation of the big post-war programs for unemployment-relief labor. The toll that is exacted by such curtailment is not appreciated by the uninformed public. Conversely, a reasonably adequate store of tested facts with which to guide repair and maintenance of locally damaged lands, would pay big dividends in terms of both resource condition and efficient use of post-war funds. But — and this is the point that seems so difficult to make — Research cannot develop these facts after the war. Fact gathering must go on now — or facts won't be available when needed. In this connection it is significant that post-war planning is a part of the war picture; it is a "must" job during the war.

It is believed neither timely nor appropriate to attempt, in this year's report, to include all projects and to record all that has been done on them during the year. A broader treatment seems more in order. The attempt has been to project our research picture, in broad outline, against the backdrop of war conditions. Discussion has therefore been confined chiefly to (1) selected examples of results, conclusions, or developments with new meaning; (2) indications of current thinking and reorientation; and (3) a look at the job ahead.

FOREST MANAGEMENT

PINE REGION

In keeping with this year's policy, only exceedingly scanty allusion is here made either to the many unsolved problems that face pine management research or to objectives, scope, past accomplishments, or status of the numerous units in the five accepted groups of closely related studies: (1) harvest conversion cuttings in old-growth stands, (2) improvement cuttings in young stands on restocking cut-over lands, (3) methods of forest regeneration where reproduction has failed, (4) silvical studies, and (5) mensuration. Many of these voluminous details appear in previous annual reports. The remainder must be left, for the moment, to progress reports. However, allusion to a selected few findings and conclusions to date seems essential for setting forth the basis of our recurrent appraisal of the project.

Results and Reorientation

The following appraisal by groups of studies has been colored by two assumptions that are believed to be sound: (1) it seems probable that cutting will continue to increase in both private and public forests in young as well as old stands; (2) increased work load and declination in the force of experienced men may combine to accelerate forest land deterioration, also our data increasingly indicate that land once deteriorated cannot be reclaimed at will.

With respect to harvest cuttings, it is to be expected that the principal problem — successful conversion cutting in old growth — will be accentuated in accessible areas, especially in pine stands. In this field, a summary of available data adapted for application which might prove of considerable immediate value is suggested for first attention. This summary probably would cover subjects outlined in a resumé of findings in this project presented and favorably received at the recent Regional Training Camp for administrative officers. In the next few years the highest degree of skill, adaptability and resourcefulness should be exercised in directing cutting in the limited remaining better accessible virgin stands, if areas are not to be deteriorated. This would be true even if there were no war. The silviculture, geared to local conditions, that is indicated will necessitate important departures from present practices.

For ponderosa pine, the approach to more intensive management has been clarified to a considerable extent by studies begun in 1911 and by the Blacks Mountain project. A summary of Blacks Mountain results should be made now, not only for possible applications, but also to aid in planning the future of the project, now more uncertain than ever. Certain conclusions seem well enough established that little risk would be experienced with their adoption in national forest management. Demonstration cuttings aimed at preventing insect damage, covering 2,700 acres in the last four years, indicate that insect losses can be reduced as much as 80 to 90 percent by the tree

selection system being tested at Blacks Mountain. Although entirely satisfactory conclusions cannot be drawn as to the effects of this preliminary salvage-control treatment on forest management costs, the returns from cutting 11½ million feet indicate that lumbering conversion costs should not be greatly increased. Where complete liquidation in forestry or lumbering must be deferred, the savings in timber from preventing insect attacks should more than compensate for extra logging costs. Where insect, timber and market conditions warrant, a more flexible management is indicated.

It is believed also, that it is now timely to explore the possibilities of general use of current inventories to direct cutting, as practiced at the Blacks Mountain Experimental Forest -- both in normal times and in the present emergency. For example, surveys of the Bureau of Entomology and Plant Quarantine indicate that the beetle epidemic has passed the peak and losses are expected to be low for at least one more year. The increased demand for lumber and the restrictions on equipment essential to truck logging will tend to concentrate cutting where railroads can be used. These lumbering requirements make it undesirable to cling to the system of uniformly distributed reserves and doubtless will make impracticable light insect control cutting. Cutting along spurs within reach of jammers and large landings will be in order. The aim should be to locate cutting concentrations where they will not cause loss of area control -- that is, in sections generally well stocked with young growth, and, in those sections, in the detailed locations well stocked and not likely to be taken over by brush. The volume reserved need not be less than now, but it would be made up by relatively heavier leaves where risk of bugs is low, where restocking will require careful, extended treatment, and in the less accessible places. Both the insect situation and the possible use of low-grade timber favor this. Current records of insect populations, reproduction and brush distribution, and timber values would make such variable cutting possible.

Preliminary analysis of findings indicate an even more urgent need for flexible management in the mixed old-growth types. Where insect, timber, and market conditions warrant, a more flexible type of management, as aimed at in the Blacks Mountain experiment, seems justified. In these types main emphasis should be placed on area control rather than on prevention of volume losses. Concentration of cutting locally where restocking is assured probably would have little adverse influence on pine losses and would help to control brush and fir. The possibility of crowding more fir into defense uses should be attempted. This would permit much needed stand improvement -- even to the extent of recutting some sale areas now choked with fir. Some production control to conserve high-grade timber would cushion the post-war collapse of the timber industry, as well as conserve soil.

As to intermediate cuttings in young pine and mixed stands, the present piling market provides nearly ideal intermediate utilization in 60- to 80-year-old second growth on good sites, because

white fir and Douglas fir, as well as ponderosa pine, are acceptable and the desired trees are declining dominants whose cutting benefits the final crop trees most. A memorandum for piling cutting has been prepared at the request of the Region to aid in any quick action, for this piling market may not last long. Should exigencies of national defense require that Division efforts be reoriented, plans for cutting in the Challenge proposed experimental forest will be rushed to supply defense needs, to take advantage of commercial cutting, and to get much needed experiments started. Both at the proposed Stanislaus and Challenge experimental areas, administrative withdrawals should be consummated as soon as possible.

In private old-growth operations, which still present the greater danger of land deterioration, there is no evidence as yet of any great intensification of the danger through general reversion to former extremely destructive logging methods or heavier cutting per unit of area; but more areas are being entered. If the defense market should continue, and railroad and donkey or skidder logging should become increasingly necessary, the danger of land deterioration would be expected to increase. Here again, it would be of great benefit to forest lands in mixed types if Douglas fir, white fir, and low grades of ponderosa pine could be required for many temporary defense needs. It is believed that studies already completed would be ample to formulate simple types of cutting restrictions that might be needed.

Experience gained in stand improvement also may contribute to prevention of land deterioration under pressure of wartime cutting — more especially if some of the defense drain could be diverted to lower grade trees and less popular species, and if cutting can be intensified locally. Not only thinning, but all cutting, and planting and silvical studies, indicate conclusively that our pines should be managed on the principle of maintaining dominance of the crop trees from the first. Application of this principle to harvest cuttings would mean that codominant or lower grade trees of groups — especially if leaning, unsymmetrical, or crooked — would not be acceptable as reserves. A war market might admit of the necessary thinning from below. In younger stands, thinning should be done earlier than was the case in our "depression", or "recovery" program, and should be repeated. Instructions to be prepared for stand improvement will stress maintenance of dominance rather than rescue of declining pines, and will be aimed principally at post-war recovery work programs.

The wartime drain on the forests can be directed in less harmful channels if good information, and simple, effective plans can be kept current. The needed surveys will have to be made with extreme economy of time, funds and technical services, yet must be efficient and dependable. Plans for the type of fact gathering and the analytical work required should be prepared by adaptation of methods developed in this division for cut-over land, management plan, and vegetation surveys.

Regeneration and silvical studies show that emphasis should be placed on preventing loss of soil control rather than on reclamation of neglected areas. The importance of this is magnified under emergency conditions when burns may be larger and more frequent, and cutting intensified. A more discriminating and varied type of cutting will do much to prevent the increase in brushy wastes, but fill-in planting should be a part of every cutting plan. Under wartime conditions, especially, the planting of well established brushfields should be deferred. Fresh timber burns should rank first in planting priority, with portions of sale areas, not likely to restock naturally, as second choice. To enable prompt planting, the capacity of Regional nurseries should be increased. Investigations of some fourteen factors involved in planting (such as site preparation, time of lifting and planting, root length, tree size, etc.) indicate that the average survival and growth in plantations of ponderosa and Jeffrey pines, in recently cleared locations, can be maintained at reasonably high levels by combining small advantages of numerous features.

Direct seeding should be used to supplement planting to speed up reforestation of large timber burns. To this end large supplies of seed should be collected this fall and stored according to tested methods of refrigeration. Ponderosa, Jeffrey, and sugar pines should be favored, if seed is generally available. Douglas fir, cedar, and true firs should be used, if choice is limited and the value of these trees must be weighed against that of brush.

Success from planting is much more likely if the planting is done immediately after the soil has been disturbed and freed of other vegetation by cutting or burning. Delay means failure or excessive site preparation costs. The damage from brush invasion and soil erosion which follow burning, usually is more serious than loss of timber killed. Protection is not completed by extinguishing the fire. Reforesting the burn ranks with fire fighting in national defense.

Plans for 1942

General consensus of opinion in the Annual Investigative (or Planning) Committee meeting just held strongly favored a major shift in effort of this pine management project for the coming year. Under war pressure and other circumstances, a heavy diversion of our limited specialized abilities and facilities to the application of research results, in close collaboration with the Regional Office, was urged. Specific recommendations, suggestions and opinions included:

1. Speeding up completion of reports of studies having the most urgent practical bearing.

2. Stress, even at the expense of some lessened output of formal publication, more informal within-service memoranda and summaries — thereby avoiding a considerable portion of the bottleneck of background material, analysis procedure, literature search and citations, finished drafting, boards of review, editing and printing. (This applies in varying degree, to the other divisions of the Station also.)

3. Assist the Region in the preparation of instructions for cultural practices wherever our results are acceptable for application.

4. Assist the Region in training new men in new procedures, especially where needed services must be made for the duration with extreme economy of time, funds, and technical services, yet must be efficient and dependable.

5. Assist the Region in putting into practice more efficient sampling and analytical procedures. Plans for such effective sampling and analytical work could be prepared by adaptation of methods developed in this division for cut-over land, management plans and vegetation surveys.

6. Participate with the Region in preparation of plans most urgently needed for guiding cutting in experimental areas in which cutting is expected soon (such cutting is desirable from every aspect). However, if we are to capitalize on opportunity, treatments must be directed according to sampling plans that will insure some valid measure of cutting effects.

7. Terminate all short-term studies that can be salvaged quickly. (There are a very few of these and specific recommendations are not yet completed.)

8. Maintain those long-term studies of greatest importance that would be lost without some attention and that can be cared for on a minimum maintenance basis to insure continuity of records by manpower remaining from higher priority jobs.

The extent to which this major orientation of the Division can be accomplished, if approved, is dependent in large measure on the final decision regarding continuance or temporary cessation of the logging experiment at the Blacks Mountain Experimental Forest. Extreme uncertainty regarding availability of CCC labor for this project next year, virtual absence of any labor reservoir from which to hire paid logging crews, and other considerations may force us to put this project in "cold storage" during the coming year. If it is decided to continue logging, even on a reduced basis, the manpower possible to release for the urgent wartime needs discussed in the foregoing paragraphs will be proportionately reduced.

FOREST MANAGEMENT

REDWOOD REGION

From a backward glance over 1941 the redwood project finds itself in a somewhat different position than the pine project. Headquarters of the new Yurok Experimental Forest (establishment of which was noted in last year's report) were nearly completed; but the timber inventory and development of roads and other facilities must be completed before the contemplated harvest-cutting experiments based on tree selection can be initiated at this branch station.

Results and Reorientation

Owing to the foregoing facts, the portion of the redwood program centered at the Yurok Branch Station offered but little opportunity for a shift of emphasis during the year, except in the direction of minor replanning in anticipation of probable war-period delay in completion of the Yurok physical plant. The ultimate objective is development of cutting methods that will insure efficient conversion of the ancient redwood commercial forests to fully productive managed stands.

Progress made on the second objective, completion of the regional redwood studies upon which efforts have been centered for the past several years, fits in well with the increasing need for making results available to the industry. For example, the difficult and time-consuming studies of volume and taper of redwood trees have been completed and the results released in the form of comprehensive volume and taper tables which supply a long-felt need in the redwood region. The results of a study of the increment of redwoods left after logging in Humboldt County will soon be available through an article recently submitted for publication in the Journal of Forestry. This will make possible more reliable estimates of the yield of residual redwood stands by showing the effect of site and diameter (at time of release) on subsequent increment. Other findings of practical importance have been revealed by an analysis of records of the first 3 examinations of planted-tree plots. Height growth was found to be significantly greater in Humboldt than in Mendocino County, and also greater on areas planted within 2 years after logging than on areas planted more than 2 years after logging. Associated vegetation was also found to have significant relation to height growth of redwood. The fern and vine-like shrub type apparently is the most favorable. In order to make available more quickly the most significant findings in the material previously submitted for a departmental publication — "Possibilities in the regeneration of redwood cut-over lands" — it is now planned to prepare two or three articles of more limited coverage. Each will deal with factors that affect natural reproduction on redwood cut-over lands. Results of the 5-year study of reproduction in the Henry Creek area will be included in the first of the above articles.

Important special jobs during the year, undertaken chiefly in response to specific requests included: (1) writing of "Recommendations regarding rules of forest practice — redwood region" on the request of the Washington Office, (2) supplying resource data and other assistance to Prof. Barr for his report to the National Resources Planning Board on the northern California redwood region, (3) cooperating on the redwood milling study at Scotia, and (4) assisting on the redwood lumber census.

Plans for 1942

In 1942 and for the duration of the war the redwood division, to the extent that its services are not needed on more essential jobs, can within its own field contribute most effectively by supplying information and direct assistance that will (1) increase the efficiency of lumber production without a lowering of standards of woods practices, and (2) decrease the fire hazard and the damage to residual stands through better slash disposal practices.

One job of high priority is the development of marking rules for use on redwood sales of national-forest timber. If, as appears probable, redwood sales are initiated on the Northern Redwood Purchase Unit a redwood-tree classification will be needed for administrative marking of timber. Some preliminary work on this study was done in 1941, and a tentative classification should be drawn up this spring. It could then be improved by checking in actual use on Forest Service sales. Our knowledge of redwood logging, slash disposal and other phases of management should also contribute to the establishment of Forest Service procedures and policies in the administration of redwood sales. At the same time going sales will be valuable proving grounds for preliminary testing of methods proposed for conduct of the future harvest-cutting experiments. This will aid in avoiding costly mistakes when long-term experiments are undertaken on the Experimental Forest.

Shortage of fire-suppression manpower and increased hazards from incendiaries will increase the severity of the fire-control problem in the redwoods as elsewhere along the West Coast. It will be important, therefore to exercise unusual care in the burning of slash and also to prevent as far as possible accumulations of heavy slash over large, continuous areas. Full cooperation on this problem should be given Administration and the industry, both to reduce the slash hazard and to prevent unnecessary damage to residual stands.

In line with the policy principle, stated earlier in this report, it is proposed to make available as rapidly as possible the results of studies which will contribute to increased production and to the protection of future forest values. An effort will be made to complete in 1942 the following two manuscripts, which would contribute to the above objective: (1) "An analysis of redwood logging costs for Humboldt County", including cost index curves, and (2) "Factors affecting the establishment of natural reproduction."

The above proposals for 1942 are based on the need for reorientation of the redwood program to immediate war needs. However, harvest-cutting and tree-selection experiments on the Yurok Experimental Forest retain their status as highest priority jobs, whenever the normal program can be restored. For this reason if manpower is available, even for short periods between jobs of more immediate importance it will be utilized to continue the job of inventorying the experimental area as the first step in the preparation of a work plan for future cutting experiments.

FOREST MANAGEMENT

FOREST FIRE PROTECTION

The fire problem analysis completed during the early spring clearly indicated (1) the necessity for continued aggressive attack in the field of fire behavior; (2) the desirability of slightly reorienting present work in the field of fire control; and (3) an urgent need for productive research outside these two fields — but work which cannot conceivably be handled with present research resources.

Results and Reorientation

Reductions in both regular and emergency personnel have resulted in a definite reduction in the rate of production of research results in the behavior field. Nevertheless, considerable progress was made on the continuing studies of controlling factors and their influences on fire rate of spread. The study of field test fires had to be abandoned because of insufficient help, but all other going work was continued on a somewhat reduced scale.

In the field of fire control, most effort was confined to going studies in order to bring them to a logical stopping place before undertaking new work on studies that the problem analysis indicated to be of currently higher priority. With this objective in view, field work was completed on a number of studies and is progressing on others at a rate expected to bring them to conclusion during 1942.

Specific contributions to fire-control practice during the year included: publication of the results of a study in collaboration with the Region, on the desirable size of suppression crews for different rate-of-spread types; an analysis and field study of the detection problem on the Angeles National Forest, which is unique in that only 10 percent of its man-caused fires are discovered by the lookout detection system; and development and incorporation in the Regional fire-danger-rating system of a method for integrating with other factors the seasonal influences of herbaceous and brush type vegetation on fire danger.

In addition to these direct contributions to fire control within the Region, definite progress toward future contributions was made through completion of field experiments in the study of the visibility of test smokes by lookout observers; completion of a preliminary report on the past fire history of the Angeles National Forest; completion of the cooperative study with the Massachusetts Institute of Technology and U. S. Weather Bureau on forecasting problems involved in the meteorological aspects of lightning-caused forest fires; the accumulation of much needed experimental data concerning (1) weather and fuel-moisture relationships; (2) the behavior of wind as it influences the measurement of wind for fire-danger-rating purposes; and (3) the accumulation of additional data regarding the influence of fuel size and arrangement on fire rate of spread.

Plans for 1942

Present plans are predicated upon the assumption that the present war emergency will not result in demands upon the fire research organization for special services much beyond the usual extent. It is expected that curtailed resources will, in general, reduce rather than eliminate progress on going work on fundamentals upon which improvement in fire control must rest.

During the next year then, the main points of emphasis seem fairly clear. Work on fire behavior will be concentrated on the going studies of weather and fuel moisture relationships, wind movement in and adjacent to forest stands, and the characteristics of forest fuels which must be evaluated in the determination of the influence of fuels upon the rate of spread of fire. In the control project the atmospheric-visibility study will be completed with analysis of the past year's test-smoke visibility data. The study of southern California past fire history will be completed with preparation of reports for all the southern forests. The soil sterilization study will be extended through investigation of the herbicidal characteristics of mixtures of boric acid and borax. The study of more efficient use of water and chemicals in fire suppression will be pushed in view of the greatly increased demand for and use of tank truck and other water-using equipment to cope with emergency needs. The study of organization management in the control of large fires will be continued with secondary priority.

An important job yet to be accomplished is development of a problem analysis for the southern California forests. Upon its completion the southern California needs for research must be weighed against the over-all Regional needs. Decision must then be reached as to the advisability of undertaking new work in the south at the present time in view of the dwindling research personnel and the recognized importance of a number of Regional problems. Only a fraction of recognized needs can be met with facilities in sight.

The foregoing proposals for concentration of effort of the Fire Division, may be modified, of course, by war needs not yet apparent. This much is clear; fire protection, as an administrative responsibility, has taken on vastly increased importance since December 7. Our long rainless summer, the concentration of vast airplane factories, ship-building plants and other defense industries, the danger of sabotage, etc., — all add up to a fire problem of vastly increased magnitude and difficulty. The specific role of fire research in the war effort has not yet been defined, but it seems only logical that it should be expected — and implemented — to play an increased part.

FOREST MANAGEMENT

FOREST GENETICS

The work of this division is perhaps less widely known and understood than that of any other. For example, in the absence of an opportunity to hear a simple explanation, many laymen hold the erroneous impression that results from this line of research can only be expected so far in the future that they have no practical values now. The actual case is of course quite different. Genetics has a surprising potential contribution to both current and post-war forest management programs. Selected examples of developments during the past year will give point to this statement.

Results and Reorientation

For the purpose of this report, the various lines of genetics research have been combined into two primary projects: one, the production of hybrids and new plant forms — to be called "Breeding", and the other dealing with all phases of selection of desirable material — to be called "Segregation". (A third project, "Propagation" is set up to facilitate record keeping. As the work merely contributes to one or the other of the primary projects it requires no separate discussion.) This treatment will simplify discussion of the work although less detail can be included in project sheets. It will also assist in integrating and directing the work toward a definite goal, as staff members will contribute to and be jointly responsible for the success of each project.

Breeding

In this subject-matter field a review of the records of production of new forms of pine reveals a steady trend toward sharper focusing of effort. Relationship groups where crossing may readily be done have been roughly outlined by experimental hybridizing. Techniques and procedures best suited to the needs of pine breeding have been selected. Devices and methods for producing mutations by physical or chemical shock have been tested, most of them being discarded as not applicable to work with pines. Only by trial and adaptation was it possible to select suitable procedures for this work from among the many possible choices. A small amount of purely investigative work is necessary to keep abreast of genetics advancement, but a great portion of the "spade work" in pine breeding is done. The breeding program is now directed toward a few well defined objectives. At the request of Dr. Haig, production of seed of two hybrids was attempted for use in New Jersey. These hybrids, Pinus rigida x Taeda and P. echinata x rigida, perform well in Placerville and their combination of hardiness with rapid growth rate and good form make them promising candidates for trial in that locality. From 3,000 to 10,000 seeds are expected of these hybrids. This test was also used in working out methods for economical mass production of hybrid seeds.

In addition to a few species crosses numerous crosses were made between varieties of ponderosa pine. Theoretically this attack offers the best chance of producing trees having outstanding growth rate. Practically, the great diversity of those varieties insures the production by combination of characters of new forms with definite advantages for use in certain parts of the ponderosa pine belt. Because two years are required for their maturation, seeds of species hybrids already made must be planted for two more seasons, and hybrids and mutations produced by past efforts need care, but this care will be held at a bare minimum. If a post-war planting program is contemplated, this hybridizing of varieties of ponderosa pine should be accelerated at the expense of species crosses in order that rapidly growing forms adapted to the various geographical localities may be produced in time.

Segregation

Two phases of the selection program should receive the greater part of the staff's effort in the immediate future. The first of these is testing promising material under field conditions. Much of this material looks good. Some may give an increased growth rate of 20 percent in forest plantings as judged by its performance at Placerville. To take full advantage of superior tree strains without risk of loss, field tests should be made of promising strains as rapidly as can be arranged.

The second and perhaps most important phase of segregation is concerned with the detection in the forest of hereditarily superior trees. Success in this work will enable the forester to select trees from which to gather seed for replanting, or for reseeding an area to be cut over. Two approaches to the problem are contemplated. From a study of the inheritance of characters, both good and bad, in the progenies of known seed trees it will be possible to predict to what extent like characters will appear in the progenies of forest trees. This approach is certain to yield results. As a corollary to this study, the morphology and cytology of superior trees will be compared with inferior trees in an effort to associate rapid growth rate with some recognizable qualitative character. The second approach to the problem of selecting superior trees in the forest is through a study of the concentration of growth hormone in their twigs. Preliminary work has demonstrated that concentration of hormones in young seedlings is correlated with growth rate. Whether this relation exists under field conditions in trees of all ages must be learned. This year tests of certain seed trees represented by progenies of known growth rate in the arboretum are planned.

Plans for 1942

The loss of relief labor and the exigencies of war necessitate a reorientation of the genetics program and a revision of the problem analysis prepared in 1941. No new work is contemplated. Going work has been arranged in four categories for consideration and disposal. First, studies, such as attempts to induce polyploidy, that promise no practical results in the immediate future and that can be closed

for the time being without loss of continuity, will be discontinued. Second, studies, as illustrated by the 1937 progeny test, that depend for their value on continuity, will be continued if possible. Photographic records and measurements may not be possible, but minimum care of the trees is necessary. Third, studies, such as hormone investigations and breeding for hybrid vigor, that promise immediate and important applications when successfully completed, and that can be carried with a low expenditure of effort, will be emphasized. And fourth, studies, such as breeding forms suitable for certain localities, field testing material of outstanding nursery performance, and study of heritability of good and bad characters should be given highest priority. Positive results from these tests are certain and are of immediate and important application.

Summarizing, and looking ahead beyond 1942, the application of principles that may be expected from the genetics program thus reoriented will help in some degree to cushion the shock of unavoidable overcutting of timber stands during the war period. Genetic practices and improved plant material will facilitate reforestation with better trees in the post-war period. Probably an expanded planting program will follow the war. To contribute to the success of this program and to provide the best possible planting materials for that time, the Genetics Division should concentrate its energies on testing, assembling information, making plans for the application of genetic principles to forest management, and collecting and storing all seed of trees of known superiority.

RANGE RESEARCH

Viewed in the light of mounting demands for meat and wool, skillful management of the 60 million acres of grazing lands in both public and private ownership, is immediately seen to be both more important and more difficult than heretofore. These uncultivated acres, totaling nearly two-thirds of the land area of the State, are the supporting base for a livestock industry of over a million cattle and nearly $3\frac{1}{2}$ million sheep. Range forage is indispensable.

Many of these range lands have other values also — watershed protection, timber growing, recreation and wildlife. The resultant complex question of management of these lands may be simply expressed in the language of the range: "How can they be grazed to get the most out of them, and still not hurt them?" This question faces the operator and administrator alike. It faces research, too. The need and demand for facts far exceeds the capacity of our curtailed, fact-finding plant.

Results and Reorientation

Some of the recent findings, in both the mountain and foothill phases of the work of this division have especial significance now. Examples follow.

Foothill Ranges

Of first importance in the immediate situation was the appearance last week in galley proof of the first comprehensive progress report from the San Joaquin Experimental Range. This bulletin, prepared in close cooperation with the University of California and other participating agencies, outlines the whole cooperative program of cattle-range studies in the so-called "annual type" of forage and gives trends of results to date.

A clear indication of the point at which close grazing became too close, is regarded as the most important forage finding for this type of grazing land, in relation to wartime pressures for increased meat production. Animal husbandmen and range technicians agree that the most closely grazed of the six pastures is too closely used for the good of either the cattle or the range. The animal husbandry story will be discussed in detail in the forthcoming interagency bulletin. Forage trends may be indicated in part by a few examples.

On the most closely grazed areas, in comparison with moderately grazed ones, new forage growth of sufficient height for grazing is delayed from 2 to 3 weeks, organic matter or litter on the top soil is thinning out, and height growth of forage is slightly less. Comparative yields have not been measured, but thus far they do not differ greatly. Forage cover, as measured by standard estimates of density and composition on sample plots, has not reacted

to extremely close grazing as quickly as in other range types. Cover on the most closely grazed pasture does not yet reveal changes in density and composition that are easily observed. Determination of comparative forage yield, not only under different degrees of grazing but also under different periods or seasons of use, is an example of the next steps that are urgently needed to meet a widespread demand.

Mountain Ranges

In this phase of the range program, findings and pending developments still loom large against the changed wartime background. The major accomplishment in the pine-range project during the past year was the completion of an analysis of national-forest range problems for northeastern California. This analysis is fostering still closer cooperation between national-forest Administration and Research. It has focused the attention of both on the more important problems encountered in the management of national-forest range resources, and on specific problems which should be investigated as rapidly as research funds can be made available. It will serve to improve present range management because it contains the essence of four years of intensive range research data and the practical ideas of range administration. It will tend to prevent hasty action leading to mismanagement as it indicates many of the critical factors in range management. It has oriented research effort on the most pressing problems in keeping with present funds and manpower and will serve as a background and guide for any future action that may be demanded of Research or Administration by the present or post-war situation.

Of the many problems presented in the analysis, four stand out:

1. Determination of the best season of use of cut-over pine and meadow types used in conjunction with one another. (A detailed working plan prepared for this study was reviewed by Washington and approved by Chapline in a field meeting held at the Blacks Mountain Branch during August, in collaboration with the Pacific Northwest Station).

2. Determination of appropriate species and methods to use in artificial or natural revegetation of mountain meadows. (Exploratory work by Region 5 and the Station indicates that many damaged but deep-soiled meadows can be restored. Reference: special illustrated report submitted in September, 1941.)

3. Study of the life history of bitterbrush to reveal the important factors to be considered in management which will best maintain this key browse species. (This is the most important browse plant in the eastside region, which covers approximately 29 million acres in California, Oregon and Nevada.)

4. Some continued investigation of the effect of livestock grazing on pine tree reproduction. (Future effort should be limited chiefly to sheep and timed to take advantage of good pine-seed-crop years, as discussed in previous reports.)

Preparation of the foregoing analysis has put the pine project in a very favorable position to move in the most needed direction in the future. Furthermore, research data now collected and that to be obtained in the future would apply generally to the eastside region in California which includes the most important national-forest ranges in Region 5. These forests represent 28 percent of the national-forest area in California and carry about 50 percent of the total number of permitted livestock.

Plans for 1942

Foothill Ranges

The working up of preliminary findings from the San Joaquin Experimental Range for publication afforded a vantage point for a fresh appraisal of the pasture experiments. Continuing from this point, for several months the interagency staff has concentrated attention on an analysis of the variables involved in these grazing capacity tests. This analysis, which should provide a very valuable guide for most effective handling of the experiments for the next several years, is still in progress in collaboration with Dr. Neyman, head of the Statistical Laboratory, University of California. Conclusions are not yet available.

For the year ahead, the best use of the very limited manpower that is available appear to be:

1. Completion of foregoing analysis, including reviews by cooperators and the Washington office.

2. Shifting of emphasis in the reseeding studies from testing of new species in nursery rows — the first step in the research program — to field testing of the few most promising species. Further attention to be placed on testing of such improved strains as are available.

3. Continuation of the pasture and run-off experiments without material change. Minor shifts proposed to be handled in a separate report.

4. Collaboration with Agricultural Adjustment Administration and Region 5 in preparation of simple practical guides to supplement the Utilization Standards Handbook — a high-priority job — to facilitate the checking by AAA examiners, of range conditions during the war period.

5. Probable termination of the quail management study.

Pine Ranges

With the direction of research better oriented and some essential plans prepared, all available time during this winter will be devoted to turning out manuscripts on past research effort. The major contribution will come from the work at Burgess Spring. These results bear on season of use of ponderosa-pine ranges. The data indicate the key forage plants found on the range, their time and degree of utilization by cattle related to stage of growth and moisture content, and the time these plants are most nutritious as indicated by the gains in weight of cattle. These results form a basis for judging the best season of range use in terms of livestock production.

In view of the continuing limitation of personnel in the pine project to one man, very little field work is expected to be carried out during the coming summer. Of highest priority is establishment of necessary plots in the mountain meadow adjoining Burgess Spring pasture. The Region and the Station have definitely scheduled the fencing of these plots this summer. This unit, planned but not constructed last year, will complete the Burgess Spring lay-out. It is regarded by the Region as of outstanding importance, for three reasons. First, results will be quickly yielded. (Initial comparisons of timber and meadow forage, expressed in pounds of beef, will be obtained in 2 years.) Second, both administrators and operators want the figures. And third, Administration states that results from this test will profoundly affect kind, quantity and location of range improvements which are expected to entail a big total expenditure in post-war public-works programs.

Preparation of manuscripts and other jobs permitting, the following items will be given limited attention.

1. Measurement of winter utilization of bitterbrush by deer.
2. Measurements of the survival of bitterbrush seedlings.
3. Examination of additional areas reseeded by range administration in past years.
4. Examination of survival of pine seedlings on scarified areas on Modoc National Forest plots.

FOREST PRODUCTS

Drastic retrenchment and readjustment of the program of this division has been necessitated by the assignment of its chief, L. N. Ericksen, to the Washington Office for the war emergency. Supervision of the Census work, therefore, has been delegated to the Division of Economics.

Results and Reorientation

Logging and Milling Studies

The effective attack upon the insect problem in eastside ponderosa pine by the Bureau of Entomology and Plant Quarantine and by our Division of Pine Management, at the Blacks Mountain Experimental Forest, is receiving critical attention from the industry. The practical application of this method of control is apparently being retarded only by the lack of knowledge of costs and values involved. The 1939 mill study of trees of different insect-risk class indicated that the high-risk trees are about one dollar below average in lumber realization value among trees of the same size. Because of the small sample and danger of bias these results were not published and it was planned to repeat the study on a more adequate basis during the past year. This was not possible because of drastic change in milling practice by the cooperating mill in connection with the defense lumber market. Detailed logging-cost studies were initiated during the past season at the Blacks Mountain Experimental Forest in cooperation with the Division of Pine Management in an attempt to compare the proposed insect-sanitation-salvage cutting method with the normal Forest Service cutting practice. Conclusive results will require additional field work.

One of the important requirements for the stimulation of recently increased interest in the economic aspects of improved forest practices in the redwood industry has been the availability of a reliable set of log grades for redwood. A simple log grading system, developed from a mill study of Humboldt County redwood in 1935, was used in another cooperative mill study in Humboldt County during the past year. The 1935 grades appeared to be consistent in yielding good value differentials. It is yet to be determined whether these grades are adaptable to Mendocino County where the timber is of somewhat different character. A mill study in this region has been urged by both the Forestry Department of the University of California and Region 5, who have done some advance planning for it.

The need for the so-called "standard log grades" for ponderosa pine is still recognized although they have been found inadequate in their present form. A mill study of westside ponderosa and sugar pine made last year is expected to yield a comparison of these grades with other grades used in this region and to show whether it is possible to adjust the specifications to make them workable.

Utilization Problems

One of the adjustments in the pine industry caused by the defense program is the increased emphasis upon common lumber grades. As the program intensifies it may prove fruitful to investigate the possibility of using white fir to meet part of the demand for common lumber. A recently reported shortage of oak timbers for ship building in this region places increased importance upon the possible substitution of local hardwoods for selected purposes in the increasing tempo of war effort.

The cutting of smoking pipe blanks from manzanita burls began on a relatively large scale during the past year. Data from the type map of the Forest Survey have indicated that the usable species occur widely. The limiting factor in supply appears to be the severity and frequency of past brush fires. The wood of manzanita burl is remarkably similar to genuine briarwood though somewhat less dense. Although the cost of producing pipe block in this region is considerably higher than the cost of briarwood from the Mediterranean area, investigation has shown that there is some possibility of retaining the manzanita pipe block industry on a permanent rather than a temporary basis. A mimeographed report on this new industry has been prepared, in cooperation with the Forest Survey Division, to answer the many inquiries that have been received in the past year.

The barks of Douglas fir and the true firs are known to contain varying but substantial amounts of corky material. The Forest Products Laboratory is working upon the problem of substituting this material for ordinary cork. The research department of a local industry is also interested in this material and in any other material suitable for insulation.

Plans for 1942

With the intensification of the war effort in the coming year it is expected that new utilization problems will come forward and that the plans of the Division will be subject to changes in emphasis as war needs for forest products take more definite shape. From the existing outlook and the available time of a staff of only one man, the following priorities are proposed: (1) push analysis and reporting of unreleased data; (2) serve in a consultant capacity, as needed, on utilization problems related to the war; (3) undertake, if possible, a logging and milling study in Mendocino County redwood, in cooperation with the various interested agencies.

We see no possibility of attack by this Division of such highly important war problems as (1) investigation of the supply, distribution, and availability of local hardwoods for specialized uses; and (2) currently maintained size-ups of the relation between availability and war needs of the most vital forest products of numerous grades or kinds.

FOREST SURVEY

During 1941 the Survey continued its program of bringing up-to-date its past work in the vegetation survey and developing a plan for the timber inventory yet to be started. However, considerable time was diverted from these activities to a study of possible contributions that might be made to the war effort.

Results and Reorientation

Vegetation Classification from Aerial Photographs

Past use of the vegetation type maps in fire control planning would seem to indicate their further usefulness in any planned intensification of fire protection for defense purposes. Engineering officers of the U. S. Army at the Presidio, San Francisco, to whom the maps were shown, recognized military values, particularly for planning war games in their military reservations. Accordingly they requested and were subsequently provided with a set of maps covering three such reservations. It was with these uses in mind that the Survey in June proposed two defense projects: one providing for completing as rapidly as possible vegetation type maps in blue-line print form covering 50,000 square miles that had already been mapped in the field; and the other for classifying directly from aerial photographs, the kind and density of vegetation on an additional 10,000 square miles in the north Coast Range Mountains region.

In order to be prepared to carry on the second project if called upon, sample areas were selected in various parts of the State and the vegetation was classified from the photographs and checked in the field. This resulted in a scheme of classification that was suggested for incorporation in the specifications of an army mapping project in which the Forest Service had been asked to participate. Although this suggestion was not finally approved by the Army the time spent by the Survey in developing this scheme was by no means wasted for it led to the formulation of a classification of timber and cordwood areas basic to the timber and cordwood inventory. Moreover, California interest in the military usefulness of the original scheme leads us to hope that with some modification, it will yet be approved at least for local purposes.

Timber Inventory Plan

Several years ago, following completion of an experimental inventory of the Bidwell Bar quadrangle, the Survey Division was ready to assemble a plan for a statewide timber inventory. This plan would have superimposed a line-plot sampling on a classification of timber and cordwood areas based on the vegetation and forest condition maps. Completion of this plan has been postponed for two reasons: (1) the possibility that a more valuable classification of timber and cordwood areas might be obtained from air photographs, and (2) differences of opinion as to the most suitable procedures to follow. A scheme of classifying timber and cordwood areas from air photographs has been successfully worked out during the past year.

Vegetation Survey

Up to July of 1939, field mapping had covered some 32 million acres. Since the cessation of field mapping at that time, work on the project has been restricted to analyzing and preparing the data for use in the form of maps, reports, and publications. Except for map publication through the Geological Survey where little progress is now possible owing to higher priority defense projects, the current program has comprised mainly the preparation of the following:

1. Blue-line Print Series of Vegetation Type and Forest Condition Maps.

These maps are designed to make the original type data available in simplified form pending the final map publication. The completion of 239 15-minute quadrangle vegetation type maps and 74 forest condition maps will bring this work up-to-date. During 1941, 130 and 16 additional units of the type and forest condition maps were made available, leaving only 57 and 20, respectively, to be completed. Thus this job should be cleared away early in 1942.

During the past year these maps continued to find additional important uses. The County Planning Commissions of San Mateo and Monterey Counties purchased complete sets covering their respective counties. The U. S. Army Engineers purchased a set covering the San Francisco Bay region for use in connection with flood control work. Also, as previously mentioned, the U. S. Army was provided with sets covering three military reservations.

2. Forest Survey Releases. Eight releases reporting on the vegetation types and forest conditions of 29 counties are required to bring this phase of the work up-to-date. Release No. 1 covering 3 counties, the only one so far available for distribution, has been well received particularly by local county planning commissions, fire protection agencies, public schools, and libraries. In Santa Cruz County, it is in use in both high schools and secondary schools in studies of county forest and wild-land resources. Release No. 2 covering 3 counties in Nevada is now being multilithed. These releases have especial importance in their relation to post-war planning.

Plans for 1942

New war demands on the Survey Division are expected in view of the military usefulness of special skills developed in the type-mapping work. There is no way to predict the degree of such diversion of time from the current jobs that may be necessary. Apart from such special assignments, the major directions of effort will be: (1) completion of vegetation type maps in blue-line-print form, (2) completion of Part I of a revised timber inventory plan, and (3) continue work on the Survey Releases. It has been decided to present the timber inventory plan in two parts. The first part which will be complete and ready for review by March 1942, presents the basic classifications of the timber and cordwood areas resulting from air photographs and supplementary ground work. It will consist of an Atlas folio containing among other things sample maps of two 7½-minute quadrangle areas in the Sierra Nevada illustrating the application of these classifications. One of these areas is predominantly timbered and the other comprises mainly cordwood stands.

The second part of the plan, which still remains to be done, will present the kinds of data to be collected and the sampling procedures and

intensities to be followed. Fundamental to the most efficient and productive use of Survey allotments is a sampling that will be adequate for certain minimum standards of accuracy but still no more intensive than necessary to meet those standards. To accomplish this objective it is necessary to use statistical procedures. Past differences of opinion are being ironed out, and new and improved techniques are coming to light in studies of the Blacks Mountain Experimental Forest data. Thus the immediate future should bring much that the Survey can take advantage of. It has therefore seemed best to wait until at least some of these studies were finished, particularly since there have been no immediate prospects of starting the inventory.

A third release which will report on 3 counties in southern California is nearly ready for multilithing and material is being compiled for a fourth covering 8 counties in the Sierras. During 1942 with Part I of the inventory plan and the blue-line print map series out of the way, more emphasis will be placed on this phase of the work.

FOREST ECONOMICS

During the past year this newest Station project (previously included and merged with Products) has been heavily jarred by changing events. The inspection trips of Assistant Chief Forsling and Dr. Nelson made possible the shaping of the future program in virtually final form with chief emphasis on financial aspects studies in Sierra Nevada forests. Since last summer, the war has created an immediate need for new types of economic information. Accordingly, plans have been adjusted to give highest priority to war research with temporarily lowered emphasis on financial studies. Examples of four developments during the year follow, the last three of which have direct reference to war or post-war needs.

Results and Reorientation

Vital Relation of Forests of Northeastern California to Local Economy

A Survey of the forests of Modoc County in the ponderosa pine type, which was undertaken at the request of the Regional Forester, revealed the magnitude and significance of both public and private forest enterprise in maintenance of the county standard of living. Despite leakages of one-half the potential contribution to outside areas, Modoc County residents nevertheless derive one-fourth of their total income from forests, and sawmilling is practically the exclusive manufacturing enterprise in the county. Although half the county receipts are from subventions, 10 percent is from forest taxes on standing timber which is rapidly being destroyed as a tax base by liquidation. As a result forest contributions in 15 years will be only a fraction of the present peak level with consequent dwindling of economic activity. When sustained yield and liquidation were compared as alternative utilization policies for the Alturas working circle of the Modoc National Forest, sustained yield was found preferable according to the tests of resource productivity, population, and community quality. However, the test of incomes showed that property when managed for sustained yield had greater capitalized net worth than under liquidation only when the interest rate was less than 2 percent due to low-growth potentialities of the site. An annual net growth of 160 board feet per acre at 3 percent, or 226 board feet at 6 percent would be required to make the two choices of management equally attractive. Since these growth rates are not obtainable on the sites involved, the alternative is to increase production under sustained yield by enlarging working circle boundaries, perhaps through acquisition of interspersed private timberland.

Forest Industries — A Major Manufacturing Enterprise

According to analysis of the 1940 census, which offers the latest data available, the combined industrial groups of lumber and timber basic products, furniture and finished lumber products, and paper and allied products, when compared to other California manufactures, ranked third in number of establishments (1,328), second in number of wage earners (39,834), second in wages paid (52 million dollars), fifth in cost of materials (95 million dollars), fourth in value of products (204 million dollars), and second in value added by manufacture (109 million dollars). Within these broad industrial groups, the sawmills, veneer mills and cooperage-stock mills were the most important single enterprise by every yardstick except number of establishments of which there were 142 in contrast to 269 independent planing mills. The counties of Humboldt, Siskiyou and Lassen produced over 50 percent of the total value of lumber products in the State, while the entire basic lumber industry is confined to about half the 58 counties in California — mainly the northern ones (Technical Note 17).

Population Depending on Forestry Industry

It is estimated that in 1939 in both lumber and timber basic products, and furniture and finished lumber products there were 35,000 wage earners, a total primary population of 125,000 and a total service population of 250,000. In the past two years the employment trend has been definitely upward, with the most spectacular advances occurring in the summer of 1941. Although employment increases in logging and sawmills have not been as pronounced as in remanufacturing processes such as mill work and furniture, employment in the basic lumber industry was nevertheless up 15 percent in 1941 over 1939. Spectacular gains have occurred in millwork in which employment was 40 percent more in July 1941 than two years previously. The over-all 20-percent employment increase since 1939 in all lumber and allied products signifies that between 40 and 45 thousand primary wage earners were dependent on the industry in mid-1941.

Unprecedented War Activity in Wood-using Industries

Reflecting a strong fourth quarter defense demand in 1940, lumber production in that year, which reached 1.96 billion board feet, was 25 percent above the long-time average. Based on activity for part of the year only, a still further increase is estimated for 1941 which will bring production in the year just closed to over 2.2 billion board feet, or an all-time high for California. Production kept pace with shipments for all species except ponderosa pine, but this lag, coupled with a hold-over lag from 1940, resulted in more than a 15-percent decrease in stocks. A further index of extraordinary activity is the reported 50 percent increase in carloadings in the fourth quarter of 1941 compared to the same period in 1939. The wood-requirements survey revealed such new changes as shortages among builders and

planing-mill operators of seasoned Douglas fir and ponderosa pine lumber and plywood, utilization of magnolia and southern ashes by furniture manufacturers to replace reduced supplies of alder and foreign woods, the consumption of several million feet annually by the California aircraft industry, and extraordinary demands for box lumber to meet defense packaging requirements. This container demand caused a nail shortage, a 10-percent increase in shipments of box lumber, and a 25-percent decrease in stocks; yet there was little increase in box-lumber production until the latter part of 1941. The availability of labor and machinery replacements is limited, and both coastal and intercoastal lumber shipments have been curtailed with resulting strain on rail transportation.

Plans for 1942

The extent to which the research program has already been re-oriented as a result of the war is evident from the preceding results. Plans for the future must remain flexible, but it is probable that one-half the 1942 program, perhaps more, will be immediately related to the war effort. By projects: (1) The census of logs, lumber and other timber products will require all-out effort until it is finished since it is scheduled for completion in March, several months earlier than usual, in order to facilitate planning production for war needs. (2) The survey of effects of war on forest industries will be continued as needed by Washington and the field to furnish up-to-the-minute information on present and prospective demand for, and supply of, forest products and commodities necessary to their manufacture and use including labor and transportation. Activity index charts of lumber production, orders, and shipments will be maintained weekly and monthly for the western pine and redwood regions. Charts of quarterly carloadings of lumber products, and monthly employment in various branches of the lumber industry will also be maintained. (3) Subject to prior requirements of the two preceding emergency studies, research in the financial aspects of forestry in the Sierra Nevada forests will be directed to determining the capital value and income return under alternative treatments of a selected area of second-growth pine in the western Sierras. Studies will probably be centered at the proposed second-growth experimental forest near Challenge, and will be in cooperation with the Pine Management Division. There will also be cooperation to the extent possible in the economic analysis of data from Blacks Mountain Experimental Forest. (4) The "now public domain" reports: (a) "Some social and economic effects of timber utilization and management in Modoc County, California" will be completed, and (b) "Land utilization in the northern Sierra Nevada" (the so-called five-county survey) will be resubmitted to the University of California.

FOREST AND RANGE INFLUENCES

In the present emergency the results of studies and experiments of this division, more than ever before, have particular significance. Floods causing damage to transportation and communication facilities, important industrial plants, water supplies, and densely populated urban areas may seriously interrupt war activities. This is especially true in southern California where the destruction of vegetation on mountain watersheds by fire and the possibility of resultant floods is an ever-present threat, and where the concentration of vital war industries is greatest. Likewise, other uses — or abuses — of our forest and wild lands, resulting in decreased productivity and loss of water needed by industry and agriculture can materially affect defense and post-defense production.

Our influences investigations have shown that irrespective of vegetation type the destruction of the natural cover by fire, over-grazing or similar misuse of the land, without exception, resulted in soil deterioration and reduced infiltration capacities. Consequently, flood and erosion hazards were increased and in many areas the yield of usable water decreased.

The role of natural vegetation in relation to streamflow, water utilization and soil stabilization as influenced by land use has been under investigation by this Station since 1927. Most of this work has been conducted in central and southern California in the chaparral-woodland and woodland-grass types of the San Joaquin foothills, the second-growth pine and pine-fir of the Sierra Nevada, and in the chaparral of southern California and the Coast Ranges. Some of the most critical water supply and flood regulation problems of the West are found within these areas.

The following 1941 highlights relate to water in its dual role of destructive agent and California's most vital crop.

Results and Reorientation

Rowe's Hydrologic Analyses

During the last year the work of the Department's Flood Control Surveys has afforded an excellent opportunity for the practical application of certain results of forest influences research, particularly from detailed studies conducted at Northfork and Berkeley. Through the application of these findings, the Station developed a new procedure of hydrologic analysis for use on flood control surveys. This method, which eliminates the use of constants, has been accepted by all agencies connected with the Department's Flood Control Surveys in California.

The method involves the use of hydrograph analyses, infiltration capacity measurements, calculation of soil-water yields, and various similar data. It permits determination and evaluation of the influences of individual on-site factors (such as vegetation cover, topography, and soil characteristics) on surface run-off, floods,

total water yield and, indirectly, soil erosion. Likewise the influences of changes in the on-site factors, brought about by fire, land treatments or use, can be determined. Although it is often more difficult to show flood reductions and water conservation benefits by use of this procedure than by other methods, it has the important advantage of affording opportunity to examine and evaluate individually the influences of all the on-site factors of a watershed complex affecting streamflow. It also permits the presentation of factual data showing how a specific remedial measure may affect run-off and other water relations and of the type and degree of benefit that can be expected.

Hydrologic analyses employing this method were made for the Russian River watershed in which 85 percent of the area is grass, brush and forest land. The analyses have indicated that a 20-percent reduction in flood peak of the maximum expected 50-year storm is possible through good watershed management involving improved agricultural practices, fire control and regulated grazing. For smaller storms, greater reductions in flood peaks would be realized.

Monroe Watershed Analysis

The analysis of hydrologic data from Monroe watershed of 863 acres on the San Dimas Experimental Forest has revealed certain significant facts. For example, from the start of the winter season, approximately 10 to 17 inches of precipitation must occur before groundwater recharge begins. Indirectly, this is a measure of water loss by transpiration and evaporation during the preceding dry summer and into the winter until this amount of rain has fallen. Further, it is shown that most storm flows are the result of rain falling directly in the stream channel. During the period 1934 to 1940 inclusive, only seven storms produced run-off exceeding the volume of precipitation intercepted in the streambed. This finding explains why streams may be high during storm periods while no measurable surface run-off occurs from adjacent vegetated slopes, and similarly, why streamflow may result from a storm in which rainfall intensities did not exceed the measured soil infiltration capacities within the watershed involved. It also serves to explain the very short time interval of 15 to 20 minutes between maximum rainfall intensities and subsequent stormflow peaks in watersheds of this size. These results have value in the analysis of hydrographs and other data for flood-control purposes.

Geologic Study of Arroyo Seco Watershed

This study, in connection with the flood control "action" program begun during the past year, shows that the area has been subjected to three periods of uplift and subsequent dissection during the past 25,000 years or so. The last elevation amounted to from 25 to 100 feet and occurred probably within the last 1500 years. This uplift accelerated the dissection process and resulted in the present steep-walled canyon in the lower 10 miles of the main stream channel. At many points the break in slope between the relative gentle older surface and the steep sides of the recently cut canyon can be clearly seen, and former streambed levels can be traced by relict gravel deposits.

Estimates of material removed during the formation of this last gorge indicate that during the 1500-year period the average rate of removal of material amounted to 20,000 cubic yards per year from the main channel and its immediate side slopes.

Three forms of erosion are active in the main channel: (1) periodic scouring out of accumulated debris in certain reaches, and continued lowering of the channel bottom itself; (2) under-cutting of cliffs of rock which is so fractured and weathered that it tends to wear or crumble rapidly where the stream thrusts against it; (3) continuous raveling of slopes which are kept steeper than their normal angle of repose by the annual cutting away of their toes by high winter flows.

The basic information developed by this study will aid materially in developing the detailed program of channel improvements now under way in this canyon for the control of floods and erosion. In particular, it shows to what height the streambed must be raised at various points to establish a base on which the raveling side slopes can come to rest and be revegetated. Once the canyon gradient is so corrected and the slopes and new deposits stabilized by vegetation, the amount of erosion debris carried by flood flows and the violence of the flows themselves will be very greatly reduced.

Fern Canyon Recovery After 1938 Fire

The remarkable recovery of natural vegetation on the Fern watersheds of the San Dimas Experimental Forest after their denudation by fire in November 1938, may well be referred to as an example of the recuperative capacity of southern California chaparral under favorable conditions of soil and climate and a half century of undisturbed growth prior to the burn. These watersheds occupy an area of 128 acres in the headwaters of the San Dimas drainage between elevations of 4500 and 5400 feet. Prior to the fire they were covered with dense oak-woodland-chaparral that had not been burned in more than 50 years. Heavy litter covered the ground several inches deep and the oaks (highland and canyon live oaks) had reached diameters of 12 inches and heights above 30 feet.

The fire consumed all vegetation on the south exposures except the stems of the larger shrubs. On the opposite slopes the oaks were stripped and their trunks left standing in places where the fire "crowned"; elsewhere only the organic matter on the ground was burned. These charred oak trunks and stems of larger shrubs were the only visible evidences of vegetation left on much of the area. However, destructive as the fire had been, it had not killed the roots of the oaks and sprouting shrub species, nor had it consumed all of the packed litter on the soil surface. This incompleteness of the burning is a vitally important factor in the ecology of southern California's chaparral types. The oaks and several shrub species promptly sprouted from their root crowns and by early spring, 1939, the denuded slopes were green with coppice and with a lush growth of annual and perennial plants. Detailed examinations of north exposure plots showed a ground cover density of 12 percent the first year after the fire. This

increased rapidly to 75 percent during the second year and decreased to about 70 percent last year. Herbaceous plants are giving way to the permanent shrubs and trees. Streamflow and erosion measurements indicate that the cover is now as effective as chaparral more than 20 years old growing under less favorable conditions on other parts of the San Dimas Forest.

It would be erroneous to conclude from this instance that natural regrowth of vegetation is so rapid or luxuriant on all fire-denuded mountains in California. On the contrary, recovery is usually extremely slow, requiring decades to develop the protective qualities desired in good watershed management. Where the soil has been completely eroded away by repeated periods of exposure following fire the recovery process may require centuries. In contrast, the soil on the Fern watersheds, though it averages little more than one foot in depth, was rich in organic matter stored during the half century since the previous fire and its fertility was not destroyed in 1938. The regrowth of vegetation on these burned watersheds demonstrates the importance of years of protection during which sprouting species produce strong root systems and soils develop a store of organic matter.

New Lysimeter Data

In the San Dimas lysimeters, established for studying percolation of water through soils and use of water by vegetation, an initial cover of grass (Bromus mollis) was grown to encourage the development of normal soil structure and to complete calibration of the tanks. A summary of seasonal results reveals a satisfying uniformity in the behavior of individual lysimeters under similar treatment (see Table for 1940-41 in project sheet). For example, with a total precipitation of 47.10 inches, the maximum run-off in 25 large tanks was 37.47 inches, minimum 34.66 inches; maximum seepage 0.24 inch, minimum zero.

The continuance of high surface run-off and low seepage, even under grass cover, is of interest. It probably indicates that the soil, well mixed to make it uniform when originally placed in the tanks, had not yet developed a structure favorable to percolation. The initial grass crop sown in 1940 increased infiltration by little more than one percent of the 1940-41 seasonal precipitation. However, preliminary results of the current season to date (October through December 1941, with 8.53 inches of rain) begin to show the effect of grass in increasing the infiltration rate. Infiltration in lysimeter No. 1, with bare soil, has amounted to 41 percent of the precipitation, compared with an average of 71 percent in lysimeters Nos. 2-26 in which the soil was covered with last year's stubble and a vigorously growing new grass crop.

A comparison of evaporation from bare soil with the evapo-transpiration use of a grass cover was made by supplementing run-off and seepage records with soil moisture data for two of the lysimeters (see Table in project sheet). The data indicate that the presence of grass resulted in the loss of about 6 inches more water than was lost by evaporation from the bare soil. However, this figure must be qualified by the fact that the luxuriant growth of grass had an abundance

of soil moisture available during its entire growing season, which would tend to make its use of water abnormally high. The roots penetrated the full 6 feet of soil and extended into the seepage compartments of the large lysimeters.

These various findings help to explain experimentally the results of numerous field studies. Infiltration tests made in different vegetation types of the State have shown that overgrazing may reduce the infiltration capacities of soils in grassland by 70 to 90 percent, in sagebrush 65 to 85, in piñon-juniper 35 to 65, and in woodland by 50 to 80 percent. Plowing or cultivation of these soils may result in infiltration capacity reductions of more than 90 percent. Burning of old chaparral, chamise, woodland, or forest cover results in average reductions in infiltration capacities ranging from 50 to 95 percent. Conversely, cessation of these abuses and restoration of adequate plant cover gradually improves the infiltration capacity.

Such data constitute the type of experimental evidence which is still urgently needed to determine the quantitative influences of forest and other plant cover in regulating streamflow. They illustrate also the relation of forest influences research to California's watershed problems which, from the standpoint of the general public, fall into three general classes: shortage of usable water, floods, and erosion.

Plans for 1942

Facing the fact of a wholly insufficient personnel and continued shrinkage thereof, and in keeping with the Department's defense program which stresses the importance of obtaining maximum production of forest, range and agricultural products, including water, and of maintaining maximum productivity of the land for the post-defense period, emphasis during 1942 will be placed on the issuance of publications and on investigations having the most direct and immediate application to watershed management and production problems. These include:

1. Issuance, in simple codified form for the guidance of administrative officers, of further practical rules of forest-cover management which are essential for the maintenance, improvement or restoration of watershed values. This is especially applicable in those parts of the Region where the water problems are critical.

2. Speeding up the analysis and reporting of accumulated data of use in flood control surveys and action programs, particularly in defense areas. Unpublished data from the San Dimas Experimental Forest are especially and urgently needed.

3. Continuance of the major San Dimas studies, particularly those bearing on the influences of various site factors and land-use practices on surface and sub-surface run-off, soil erosion, floods, and soil and water conservation.

4. Probable closing, at end of current rainy season, of Kings River Branch Station until such time as personnel and funds become available for its adequate operation.

5. Reduction of Northfork and Bass Lake studies to the level of minimum maintenance sufficient to safeguard continuity of most essential records.

6. Further perfecting and reporting the hydrologic analysis procedure developed by the Station for use by Flood Control Surveys and other agencies in evaluating various watershed conditions and management practices in flood control and in soil and water conservation.

FLOOD CONTROL SURVEYS

The administration of Flood Control investigations was reorganized early in 1941. Responsibility for the direction of detailed surveys now rests with one or another of the two action agencies, Forest Service and Soil Conservation Service, and for preliminary examinations with the Bureau of Agricultural Economics. Formerly these three agencies had jointly conducted all investigations under a coordinating committee with chairmanship resting either in the FS or SCS. Under the new order technical specialists of the respective bureaus are detailed on a reimbursement basis to the responsible bureau, as requested for each survey or preliminary examination, to assist in their special fields of training. Under this policy of single bureau control the surveys in California have moved forward effectively.

Since October 1940, Ilch of the Influences Division and two other foresters have been detailed to the Bureau of Agricultural Economics for work on preliminary examinations. In addition special assistance in hydrologic analysis has been given this Bureau by other staff members of the Division. The hydrologic determinations for the preliminary report on the Russian River watershed were largely developed by Station staff men. Consulting assistance in the same field was given the BAE in connection with the Middle Sacramento and Santa Clara preliminary reports.

Intensive survey of the Santa Maria River watershed was completed under Station leadership and the report is in rough draft stage. This investigation has determined flood causes and prospective flood damages in the watershed, and the report recommends a definite remedial program for execution by the Department of Agriculture on mountain and valley lands.

Survey work on the Santa Ynez River watershed was begun in September and is 33 percent complete. Incidental to this project a sedimentation survey of Gibraltar Reservoir, which holds Santa Barbara city's water supply, was made in October by the Santa Ynez Survey field party with the help of short details of men from the U. S. Army Engineer Department, the Geological Survey and the Bureau of Reclamation. To supplement the paucity of rainfall data in the Santa Ynez area, four intensity recording rain gages were placed in operation by the survey party at strategic points in the watershed in November prior to the beginning of the current rainy season.

Of special significance is the excellent cooperation with other federal agencies developed at the instigation of the Forest Service in connection with the Santa Ynez Survey. Taking advantage of the fact that the U. S. Engineer Department started its flood control survey of this watershed simultaneously with ours, that the Geological Survey had launched a long-time study of ground-water in Santa Barbara County, and that the Reclamation Bureau was undertaking a county-wide study of irrigation needs and prospects, the Forest Service initiated conferences of the four agencies. A division of labor was agreed upon for the collection and exchange of factual information which is needed by all. This plan is working to the mutual advantage of all four bureaus.

Cooperation between the Engineer Department and the Forest Service is particularly close and helpful since the major objective of both services is flood control.

Cooperation with the State Engineer, and with the University of California through the special committee appointed by the Dean of the College of Agriculture under chairmanship of Professor Frank Adams, has been continued under the previous agreement. These contacts have been very helpful not only in supplying essential hydrologic data but in discussions of technical points and in critical reviewing of reports.

Several Forest Service men were on detail to the Santa Ana Survey, under leadership of the Soil Conservation Service, for varying periods from January to September. Several men from the SCS and BAE were detailed similarly to the Santa Maria and Santa Ynez surveys under Forest Service leadership.

In the course of both Santa Maria and Santa Ynez surveys further substantial advances have been made in developing the procedure for integrating infiltrometer plot tests and watercycle experimental data with measured watershed factors for use in hydrologic analyses. This procedure has proven to be a most realistic and convincing method for calculating the probable reduction of flood flows which can be brought about by cover improvement and other remedial measures in the watershed.

LIBRARY AND STATISTICAL SECTION

Progress reported upon by the several divisions in the preceding pages has been facilitated materially by the special services of these two sections.

The functions and services of the Station library, under the direction of Anne M. Avakian, include: selective acquisition of books and pamphlets needed as handy research tools, preparation and maintenance of mailing lists and distribution of publications, circulation of material for staff reading, translations (French, German, Spanish, and Russian), and assembly of specific subject matter for lectures and manuscripts.

The statistical section, under the direction of Kathleen G. Brecheen, aided by a staff of emergency computers, handles statistical analyses as requested by the various divisions. These services, which also save much division-staff time, include both routine calculations and advisory work relating to new trends in methodology and design.

COOPERATING AGENCIES

From the very beginning, the investigational program of this Station has been built upon the firm belief in the greater research values that accrue from concerted cooperative attack on the involved problems of forest and wild-land management. Our work is, of course, closely coordinated with that of Region 5 (the administrative branch of the Forest Service in this area) which has supported our program in many ways. Cooperative studies and experiments are in progress with the College of Agriculture, University of California, our primary cooperator, and with various other agencies. The following examples will serve to indicate the scope and importance of these studies now in progress. Others are alluded to elsewhere in this report.

The highly important and practical studies and experiments in animal husbandry, an integral part of the cooperative program at the San Joaquin Experimental Range, was continued during the year without major changes, under the direction of the following University technicians: G. H. Hart (Head of the Division), H. R. Guilbert (associate animal husbandman), and Kenneth Wagon (resident animal husbandman, San Joaquin Experimental Range). Interest in these cooperative studies is widespread. Highlights of results, of immediate application value, will soon be available in the University bulletin, now in press, under the joint authorship of Dean Hutchison and Director Kotok.

Cooperative studies were also continued with the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture under the direction of J. M. Miller and K. A. Salman. These studies are vital to the solution of several forest-management problems at our Blacks Mountain Branch and elsewhere, in which entomological factors are important. Results will be presented in the Annual Report of the above bureau. (See also the "Forest Management — Pine Region" section of this report.)

Cooperative studies with the Fish and Wildlife Service, U. S. Department of the Interior, also continued under the direction of E. E. Horn, in charge of western forest wildlife research for that department. This work included the detailed studies centered at the San Joaquin Experimental Range, on the effect of rodents upon range — a very practical problem of the livestock industry. Trends of these studies also will be outlined in the forthcoming University bulletin, now in press. Cooperation with the same bureau was continued through C. L. Smith of the Denver Wildlife Research Laboratory, on the problem of rodent relations in forest planting.

The 5-agency quail management study, to be reported upon and credited in the same bulletin, also was continued. In addition to Region 5 of the Forest Service, chief financial supporter, the following agencies participated: Division of Zoology, University of California; Fish and Wildlife Service, U. S. Department of the Interior; and the California State Division of Fish and Game.

The Civilian Public Service Camp for Conscientious Objectors, established on the San Dimas Experimental Forest last June, has given substantial assistance to the Influences research program. The Camp, headed by the American Friends Service Committee, has grown gradually to an enrollment of 90 men. It operates in much the same manner as a CCC Camp, with camp maintenance and welfare of the men being handled by the Friends Committee, and the planning and supervision of work programs by the Experiment Station. The men represent a number of skilled trades and more than 25 percent have had from 4 to 7 years of college education. Following various periods of special training under the technical staff of the Forest, they are employed on a wide range of tasks including the collection and compilation of data, assisting in the laboratory, maintenance of research installations, and various hand-labor jobs. With few exceptions the men are as conscientious in their work as in their objections to war. Their services on the San Dimas Forest have made possible the continuation of several research projects which would otherwise have been seriously curtailed through decreases in other emergency programs.

In flood control investigations the involved cooperation reaches widely into Federal, State and local agencies as explained in the preceding section of this report.

Acknowledgement is due CCC, WPA and other agencies for much valued assistance in the Station's whole program. Credit is especially due our field assistants and all other temporary employees who have contributed importantly and to whom it is regretted, individual credit cannot be given here.

STAFF PUBLICATIONS

Printed

Abell, C. A.

Determining the desirable size of suppression crews for the national forests of northern California. By P. D. Hanson and C. A. Abell. Fire control notes 5(3):156-160. July 1941.

A planning basis for adequate fire control on the southern California national forests. By S. B. Shaw, C. A. Abell, R. L. Deering, and P. D. Hanson. Fire control notes 5(1):1-59. January 1941.

Amidon, R. E.

Determining the value of public works expenditures. Civil engineering 11(3):175. March 1941.

The engineer's role in planning for the future. Civil engineering 11(6):359. June 1941.

Bentley, J. R.

Automatic recording of salting and watering habits of cattle. Journal of forestry 39(10):832-836. October 1941.

Bruce, H. D.

Plot tests with chemical soil sterilants in California. By A. S. Crafts, H. D. Bruce, and R. N. Raynor. Berkeley, Calif., 1941. 25 pp. (California. Agricultural experiment station. Bulletin 648)

Theoretical analysis of smoke-column visibility. Journal of agricultural research 62(3):161-178. February 1, 1941.

Colman, E. A.

(Review of) Disturbance of forest soil resulting from the uprooting of trees. By Harold J. Lutz. Yale univ. School of forestry Bull. 45. 37 pp. 7 pls. 1940. Journal of forestry 39(6):572-573. June 1941.

Crafts, E. C.

(Review of) A selected bibliography of North American forestry. By E. N. Munns, U.S.D.A. Misc. pub. 364. 1142 pp. 1940. Journal of forestry 39(3):339. March 1941.

Daniel, T. W.

(Review of) Plant indicators - concept and status. By Arthur W. Sampson. Botanical review 5:155-206. March 1939. Journal of forestry 39(6):576-577. June 1941.

Fowells, H. A.

The period of seasonal growth of ponderosa pine and associated species. Journal of forestry 39(7):601-608. July 1941.

Hasel, A. A.

Estimation of vegetation-type areas by linear measurement. Journal of forestry 39(1):34-40. January 1941.

Horton, J. S.

The sample plot as a method of quantitative analysis of chaparral vegetation in California. Ecology 22(4): 457-468. October 1941.

Jensen, H. A.

Taking stock of California's vegetation. California monthly, pp.10-11, 44-46. September 1941.

Mirov, N. T.

Distribution of growth hormone in shoots of two species of pine. Journal of forestry 39(5):457-464. May 1941.

Forest genetics: present status and outlook for the future. Pacific science congress. 6th, Berkeley, Stanford, and San Francisco, 1939. Proceedings 4:727-730. 1941.

Roof, J. B.

Growing California's two wax myrtles. California horticultural society. Journal 2(3):167-172. July 1941.

Rowe, P. B.

Some factors of the hydrology of the Sierra Nevada foothills. American geophysical union. Transactions, 1941, pt.1, pp.90-100. 1941.

Mimeographed

Bollaert, René

A preliminary survey of utilization conditions for second-growth timber products from the western Sierra Nevada. Berkeley, 1941. 13 pp. (U.S. Forest service. California forest and range experiment station. Technical note no. 14)

Buck, C. C.

A forest fire protection problem analysis for California. By C. C. Buck, H. D. Bruce, C. A. Abell, and W. L. Fons. Berkeley, California forest and range experiment station, 1941. 143.

Crafts, E. C.

Some economic facts about the California lumber and timber products industry and size of its dependent population. Berkeley, 1941. 18 pp. (U.S. Forest service. California forest and range experiment station. Technical note no. 17)

Gruenewald, F. A.

Preliminary statement of production of lumber, lath, and shingles in California, 1940. 2 pp. (U.S. Forest service. California forest and range experiment station. Technical note no. 15)

Hallin, W.

Volume and taper tables for old-growth coastal redwood. Berkeley, California forest and range experiment station, 1941. 79 pp.

Kirk, Bernard M.

The fall plantations of the Burney Spring experiment in brushfield reforestation, 1937. Berkeley, 1941. 21 pp.

U.S. Forest service. California forest and range experiment station. California forest statistics, comp. by Forest economics and forest survey. Berkeley, 1941. 17 pp. (Its Technical note no. 16) 17 pp.

PROJECT STATUS SHEETS

Harvest Cuttings

1. Field division Forest Management Research — Pine Region.
2. Work project Silviculture.
3. Line project Harvest cuttings — mixed conifers.
4. Purpose To develop harvest-conversion cutting methods conducive to productive management of 12 million acres all-aged, mixed PP, SP, DF, WF, RF, and IC commercial forest in which drain is now 6 times growth. First objective is to prevent deterioration of remaining 8 million acres of old growth during lumbering.
5. Review of past work Results of current lumbering practices measured at periods of 5 to 10 years on sample plots established 1910-1940, in 52 groups of 1025 acre-size units; Sites I to IV; types range from pure PP through SP-F to 5 species mixtures; methods of cutting include heavy industrial, early Forest Service selection, current Forest Service selection, economic selection, shelterwood, and experimental insect control-salvage, and "flexible" selection; each tree identified to enable determining tree-class changes; records show growth, loss, causes of loss and injury, logging damage and area coverage, slash disposal effects, brush invasion, seed bearing, incidence of reproduction, survival of reproduction, development of advance growth. Additional information from complete inventories 11,412 acres virgin timber and surveys private cut-over land 1921 and 1932.

Experimentation with theories from plot work begun 1929. Five experimental forests reported on: Swain Mountain, 6,080 acres, WF-PP approved 3-22-32; Feather River, 3,970 acres mixed conifers, approved 6-27-33; Blacks Mountain, 10,252 acres PP, approved 1-28-34; Stanislaus-Tuolumne, SP-PP-WF, pending; Challenge, PP 80-year second growth pending. Improvements completed Blacks Mountain and Feather River. Inventory and working plan completed for Blacks Mountain. Woods and mill studies: SP-WF type, Stanislaus, completed 1929; PP type, Blacks Mountain, 1937 and 1939, preliminary phases completed in cooperation Division of Products. Insect control-salvage cutting experiment begun 1937 at Blacks Mountain in cooperation with Bureau of Entomology and Plant Quarantine extended to 2,705 acres with reductions in losses 78 to 91 percent. Tests special logging equipment — truck loader and power saws — at Blacks Mountain in cooperation Division of Forest Products. Five methods of cutting in PP tested on 4 annual random blocks of plots at Blacks Mountain.

Results effectuated currently by incorporation in Region 5 marking rules. Tree classification for selection stands developed, 1922. Logging damage studies hastened change to tractors from high-lead. Growth prediction and cut-over land cruising methods adopted in management plans Region 5. Results used in preparation of Lumber Code 1934, and proposed regulations

for private cutting 1941. Growth and other data used in national resource surveys — Capper Report 1921, Capper Revision 1932, Copeland Report 1932, Public Domain Report 1932, JCC hearings and report 1940. Results used in training at Region 5 Feather River school. Records form basis for following publications:

- 1922. Dunning, D. Relation of crown size and character to rate of growth and response to cutting in western yellow pine. Jour. Forestry 20:4. 379-389.
- 1923. Dunning, D. Some results of cutting in the Sierra forests of California. U.S.D.A. Dept. Bul. 1176. 27 p.
- 1926. Dunning, D. Predicting the second cut in national forest management plans. Jour. Forestry 24:7. 725-790.
- 1926. Show, S. B. Timber growing and logging practice in the California pine region. U.S.D.A. Dept. Bul. 1402. 75 p.
- 1928. Dunning, D. A tree classification for the selection forests of the Sierra Nevada. Jour. Agr. Res. 36:9. 755-771.
- 1933. Brundage, M. R., M. E. Krueger, and D. Dunning. The economic significance of tree size in western Sierra lumbering. Calif. Agr. Exp. Sta. Bul. 549. 61 p.
- 1938. Hasel, A. A. Sampling error in timber surveys. Jour. Agr. Res. 57:10. 713-736.
- 1938. Dunning, D. and A. A. Hasel. The Blacks Mountain Experimental Forest. A sustained yield experiment in ponderosa pine in northeastern California. Multilithed. 16 p.
- 1941. Hasel, A. A. Estimation of vegetation-type areas by linear measurement. Jour. Forestry 39:1. 34-40.

- 6. Accomplishments during past year Insect control-salvage cutting at Blacks Mountain increased by 906 acres and loss surveys continued in cooperation Bureau Entomology and Plant Quarantine. Five additional methods-of-cutting plots established Blacks Mountain. Papers on cut-over land cruising and line sampling submitted to Journal of Forestry by Hasel.
- 7. Plans for next year Summarize results in form of administrative reports for application during war period to prevent damage from expected intensified cutting and for post-war rehabilitation. Probably necessary help plan and direct cutting for war products (piling) some experimental forests. Cutting at Blacks Mountain may be discontinued for a year with minimum maintenance going studies.
- 8. Date of completion Continuing project with current study reporting.
- 9. Assignment Dunning, Hasel, Clements, Fowells, Drew, Morrow.

January 1942

Stand Improvement

1. Field division Forest Management Research - Pine Region.
2. Work project Silviculture.
3. Line project Stand improvement.
4. Purpose To determine methods of thinning and release cutting in pure and mixed, even-aged and selection stands of PP, SP, DF, WF, RF, and IC adapted to increase the proportion of pines in final timber crops, and to develop fir Christmas trees and other intermediate products. Results applicable to one and a third million acres of second growth where natural tendency is for firs to replace the pines.
5. Review of past work Between 1912 and 1934, 48 plots established in pure even-aged PP, DF, and SP-WF and irregular mixed species second growth, representing standard methods of thinning and local theories of stand improvement. Plots re-examined at 5- to 10-year intervals to 1940. Analysis of data deferred as economy measure. Other stand development data available from yield and reproduction studies. Cooperated with Region 5 in stand improvement program during depression-recovery period, 1933-35, in preparation of instructions, selection of areas and training personnel.
6. Accomplishments during past year Analysis of records of 27 plots for periods of 6 to 20 years begun with allotment of small portion one man's time. Rough compilation almost complete.
7. Plans for next year Continue work of analysis with view to practical type of administrative report applicable to post-war rehabilitation.
8. Date of completion Series of field trials very inadequate and completion date indeterminate.
9. Assignment Dunning, Clements, Hasel.

January 1942

Silvics

1. Field division Forest Management Research - Pine Region.
2. Work project Silviculture.
3. Line project Silvics.
4. Purpose To determine the important physical and biological site factors and their influence on principal timber trees with a view to increasing natural tree reproduction and proportion of pine in stands; preventing brush invasion after lumbering; finding efficient methods to reclaim 2 to 3 million acres of wastelands by planting; and to improve growth rates and timber quality.
5. Review of past work Records of following studies or phases of project mostly completed: Precipitation, air temperature, relative humidity, evaporation and wind movement; soil mechanical analyses, pH determinations, soil moisture, and soil temperature at three branch stations in virgin, partly cut, and clear-cut stands, and sites cleared for planting by various methods, periods of 2 to 28 years. Light intensity under selected conditions. Temperatures at various heights in trees, and flower and cone development. Temperatures under controlled and uncontrolled conditions of storage of planting stock. Causes of mortality and injury to seedlings and larger trees, including above physical factors, insects, rodents, logging, slash disposal and grazing. Occurrence of natural seedlings in relation to cutting, burning, and brush competition. Relative growth of tree species in competition. Seasonal distribution of height and radial growth of ponderosa pine at 3 stations and 5 altitudes and 4 other species at 3 branch stations. Invasion of brush in relation to cutting, logging, burning and machine clearing. Release from competition by root isolation. Tree root distribution, growth, penetration, and regeneration after pruning. Effects of poison sprays in reducing seedling transpiration and rodent injury. Moisture content of seedlings in storage and at various seasons. Seed production of tree classes, species, and stands by cone counts and seed traps 9 areas 10 years; general crop records 30 years. Seed flight and distribution numerous species.
6. Accomplishments Weather and soil stations maintained at 3 branches.
during past year Physical site factor and seedling survival records maintained at Stanislaus Branch. Period of seed fall of sugar pine studied. Site preparation of deteriorated sale area attempted to promote natural and artificial seeding of sugar pine. Effects of growth promoting substances on regeneration of roots after pruning studied. Water use by seedlings in relation to root pruning determined. Growth of seedlings studied in relation to soil moisture content and wilting percentage for ponderosa pine determined in relation to accepted standards. Assistance given University of California in study of soil attributes in relation to vegetative cover at Stanislaus Branch. Results of seasonal growth study published. Soil map of Blacks Mountain Experimental Forest completed by University of California.

7. Plans for next year Maintain principal branch station climatic records. Complete first year records for sugar pine site preparation study at Stanislaus Branch. Summarize results of studies for administrative application in connection with cutting, planting, and stand improvement.
8. Date of completion Site factor records about 1945. Other phases indefinite.
9. Assignment Dunning, Fowells.

January 1942

Stand Studies

1. Field division Forest Management Research — Pine Region.
2. Work project Mensuration.
3. Line project Stand studies.
4. Purpose To provide tables and graphs for predicting growth and yield for forest working plans and economic planning surveys.
5. Review of past work Temporary sample plots measured by Region 5 and this Station and yield tables prepared for even-aged pure stands of DF, WF, PF, PP, and Redwood, and for even-aged stands of first 4 species in mixtures, by Region 5, University of California, Pacific Northwest Station, and this Station. Results published as University of California and Department bulletins. Stand density index for even-aged stands developed and published. Development of even-aged stands followed by periodic measurement of permanent plots.

For mixed, all-aged stands, 841 acres permanent plots measured periodically 1911 to 1940 and site class, growth, and loss charts prepared and used for predicting yield in Region 5 management plans and national surveys. Method of predicting yields for selection stands from stand tables prepared and published. Results used in estimating growth and drain for several national resource surveys and plans.
6. Accomplishments during past year Yield prediction methods reviewed for three working circle plans. Manuscript on growth prediction in selection stands revised. A portion of 1940 decade field measurements made.
7. Plans for next year Complete publication on growth prediction in selection stands.
8. Date of completion Revisions required as longer records accrue. Extension of uses to continue.
9. Assignment Dunning, Clements, Hasel.

January 1942

Statistical Methods

1. Field division Forest Management Research - Pine Region.
2. Work Project Measurement.
3. Line project Statistical methods.
4. Purpose To improve methods of cruising and other types of sampling to provide efficient, current information needed in forest administration and research.
5. Review of past work Cruising for volume studies for 5 areas with complete coverage by small units aggregating 11,412 acres and results published in Jour. Agr. Res. November 15, 1938.

Line-plot method of sampling for timber volume, and linear measurement method of sampling vegetation areas studied and reports published.

Method of cruising sale areas designed to reveal short term, small changes prepared for Region 5.

Aerial photographs of Blacks Mountain and Stanislaus Centers provided by Region 5 as basis for tests of forest survey sampling methods.
6. Accomplishments during past year Formulae deduced for estimating timber volume for non-rectangular blocks from strips and line-plots that avoid bias of previous methods and increase accuracy, and report submitted for publication. Assistance given in sampling for Alturas (Modoc) Working Circle plan. Sampling procedure reviewed for Michigan-California Lumber Company, report prepared by Division of State and Private Forestry. Assisted Office of Blister Rust Control, Bureau of Entomology and Plant Quarantine, in sampling and statistical work of Ribes and sugar pine surveys. Aid given Range Research in planning studies. Work begun with Forest Survey in developing sampling methods from Blacks Mountain air pictures. Sampling procedure outlined for administrative study on Lassen National Forest.
7. Plans for next year Sampling studies to be summarized for timber management in war emergency to enable collecting quickly information needed to direct intensified cutting in such a way as to avoid damage to areas and stands. Field instruction and consultation in application of methods.
8. Date of completion Continuing.
9. Assignment Dunning, Hasel, Clements.

January 1942

Tree Studies

1. Field division Forest Management Research — Pine Region.
2. Work project Mensuration.
3. Line project Tree studies.
4. Purpose To provide an adequate series of volume tables for six commercial species, suitable for requirements of timber industries, public land agencies, forestry schools and consulting foresters.
5. Review of past work Many thousand tree measurements made between 1905 and 1936 by Region 5, State Board of Forestry, University of California, and this Station. Of many tables prepared 88 still useful, of which 36 prepared by this Station. Current assistance in checking and application of tables. Tables are used extensively by nearly all forest agencies and industries.
6. Accomplishments during past year None.
7. Plans for next year A Jeffrey pine table will be prepared. Some revision in form of tables may be necessary to reduce scaling load as a war emergency.
8. Date of completion Checking and revision to continue indefinitely. About 15 modern old-growth tables should be prepared and published in better form for general use.
9. Assignment Dunning, Clements.

January 1942

Planting and Seeding

1. Field division Forest Management Research — Pine Region.
2. Work project Regeneration.
3. Line project Planting.
4. Purpose To develop practical methods of planting and seeding to enable reforesting current burns, deteriorating cut-over lands, and extensive northern California brush-fields and timber sites. Three and one-third million acres now require complete or partial planting.
5. Review of past work Practical tests of direct seeding 1908-1913 mostly unsuccessful. Tests with planting stock continued 1913-1920 and results published in U.S.D.A. Circ. 92 by S. B. Shaw and applied in Region 5 administrative planting to date. Research resumed in 1929 including studies as follows: Direct seeding with rodent screens; with site poisoned for rodents; with seed treated with rodent poisons; with stratified seed; by seed spots and with corn planters; for comparisons of 4 tree species; with 5 types of site preparation; and at various seasons. Planting nursery stock of 3 species; with stock of several grades; with various types of site preparation; at different seasons; after different methods of stock storage; with stock treated with rabbit poisons; and with roots pruned to different lengths. Related work under silvics, seed, and nursery projects.
6. Accomplishments during past year Field records completed for studies of season of planting, methods of storage, and grades of ponderosa pine and Jeffrey pine stock. Comparisons made of field survival and growth of Jeffrey pine stock from different seed grades, seedling grades, and transplant grades. Study of effects of lifting at various seasons continued. Fifth season records completed for comparisons of species, brush eradication treatments, poison sprayed stock, spring and fall planting, planted stock and seed spots.
7. Plans for next year Minimum field maintenance of studies in progress. Summarize results since 1929 applicable to planting to prevent loss of area control that may result from accelerated cutting and burning during the war and for post-war rehabilitation.
8. Date of completion Continuing project with current reporting of completed phases.
9. Assignment Dunning, Fowells, Morrow.

January 1942

Seed Studies

1. Field division Forest Management Research — Pine Region.
2. Work project Regeneration.
3. Line project Seed studies.
4. Purpose To determine behavior of seed of timber trees in relation to collection, storage, nursery practices, and direct seeding — fundamental facts needed for all future reforestation.
5. Review of past work Germinative capacity in greenhouse and nursery, season and dates for sowing, and proper depth of coverage determined for timber species, 1913-1920, at Feather River Nursery. Results published in U.S.D.A. Circ. 92 by S. B. Show. Seed size in relation to germination and grades of 1-0, and 1-1 stock determined. Germination in relation to character of surface determined, 4 species. Other information on crops, etc., available from silvics and direct seeding studies.
6. Accomplishments during past year Specific gravity during period of ripening of sugar pine measured and germination tests begun. Instructions for pre-germination treatment of large quantities of ponderosa pine and Jeffrey pine seed prepared for Region 5. Seed stratified and tested for U. S. Fish and Wildlife Service for rodent control experiments. International Union Forest Research Organization's Scotch pine provenience study continued.
7. Plans for next year Finish germination tests sugar pine ripening study. Finish transplant phase of Scotch pine provenience study.
8. Date of completion Continuing short-term studies as required for other research and administrative planting.
9. Assignment Dunning, Fowells, Morrow.

January 1942

Forest Nursery Practices

1. Field division Forest Management Research — Pine Region.
2. Work project Regeneration.
3. Line project Nursery practices.
4. Purpose To develop nursery stock suitable for planting successfully current burns, deteriorating cut-over land, and extensive, old, northern California brushfields on timber sites.
5. Review of past work Trials of 1-0, 2-0, 1-1, 2-1, and 1-1-1 stock of timber species tested; top-root ratio criterion for grading stock developed; routine for sowing, spacing, mulching, shading, watering, transplanting, root-pruning, and packing worked out by studies, or empirically, at Feather River Branch, 1913-20; results published in U. S. D. A. Circ. 92 by S. B. Shaw and generally adopted in Region 5. Short-time studies 1929 to date include effects on survival and growth of seed size; 1-0 seedling size; 1-1 transplant size; season of lifting; condition of buds; method of temporary storage; length of root-pruning; age at root-pruning. Feather River Nursery maintained to produce 20 to 80 thousand trees for experiments.
6. Accomplishment during past year Study of root-pruning in place begun at Feather River. Tests of fertilizers on two nursery soils begun in attempt to improve quality of ponderosa pine and Jeffrey pine stock. Trial of ponderosa pine seed selected by Genetics begun. Feather River Nursery production: 22.5M, 1-1; 15.3M, 1.0; 49.8M, sown for 1943.
7. Plans for next year Carry study of root pruning in place through to planting phase. Complete fertilizer study. Maintain seed source studies, and keep up nursery production for these and other incomplete planting tests. Summarize results of short-term studies for use of Region in planting.
8. Date of completion Continuing short-term studies.
9. Assignment Dunning, Fowells, Morrow.

January 1942

Harvest Cuttings - Natural Regeneration and Yield
as Affected by Cutting Methods and Slash Disposal

1. Field division Forest Management Research - Redwood Region.
2. Work project Silviculture.
3. Line project Harvest cuttings - natural regeneration and slash disposal.
yield as affected by cutting methods and
4. Purpose To determine the best methods for converting private and public commercial virgin redwood stands to managed stands with maximum sustained yield.
5. Review of past work It has been demonstrated that natural reproduction is most readily obtained on selectively cut areas; that steam logging (particularly with slackline) and broadcast burning are destructive of the currently unmerchantable part of the stand, including trees 30 or more inches in diameter, and create conditions unfavorable for regeneration, either artificial or natural; that small flexible yarding equipment (such as tractors) are best adapted to selective logging and are more efficient than steam under most redwood conditions, and that slash on selectively logged areas can be largely disposed of by controlled burning without serious crown damage to residual trees. Basal damage can be greatly reduced by preventing slash accumulation about residual trees during logging. Henry Creek study indicates minimum economic diameter limit of 36 to 40 inches, leaving reserve of 30 M to 40 M per acre, natural regeneration generally adequate but heaviest following medium to heavy slash burn. Mendocino County logging studies show sharp rise in costs for felling, peeling and yarding with decrease in tree diameter below 36 inches. Bucking and transportation costs little affected by tree diameter. Analysis of data from 1,000 cores from 400 redwoods left 10 to 50 years since logging completed. A problem analysis for silvicultural investigation in the redwood region submitted. Fifth year examination of Henry Creek reproduction quadrats completed. The Yurok Experimental Forest for the northern redwood area established and studies in methods of converting the virgin forest to managed stands through selective cutting given first priority.

6. Accomplishments during past year Inventory methods for Yurok Forest developed and 100 acres covered. Manuscript on increment of residual redwoods showing effect of site and diameter at time of release on increment submitted for publication. Material originally submitted for departmental publication - "Possibilities in the regeneration of redwood cut-over lands" - withdrawn and decision made to publish as two or three non-departmental articles. Data from Henry Creek production quadrats analysed for inclusion in first of these articles. Cooperated with Products on redwood milling study. Work begun on redwood tree classification - bark characters apparently most useful.
7. Plans for next year Complete manuscripts on: (1) Some factors affecting establishment of natural redwood reproduction. (2) Analysis of redwood logging costs for Humboldt County including cost index curves. Develop redwood tree classification system, cooperate on timber sales procedures and slash disposal. Continue inventory of Yurok Forest.
8. Date of completion Indefinite.
9. Assignment Person, Hallin.

January 1942

Tree Studies - Redwood and Port Orford Cedar
Volume and Taper Tables

1. Field division Forest Management Research - Redwood Region.
2. Work project Mensuration.
3. Line project Tree studies - redwood and Port Orford cedar volume and taper tables.
4. Purpose Preparation of volume and taper tables for redwood and Port Orford cedar, needed in lumbering operations on private and governmental lands and in forest management research.
5. Review of past work Study of available tables and methods applicable to redwoods begun in 1935. Measurements taken on 850 trees 1935-38. Redwood volume tables prepared for 5 top diameter-basal diameter ratios; 50, 60, 70, 80 and 90 percent of diameter i.b. at 20 feet above base. Schumacher logarithmic method used. Applicability of these tables to different areas checked by use of all collected data and data loaned by Pacific Lumber Company and Professor Fritz. Preliminary Port Orford cedar volume and taper tables prepared from measurements on 80 trees. Two redwood taper tables were prepared for portion of tree below 12-inch top by use of regressions using percents of diameter and heights. Two volume tables prepared from taper tables.
6. Accomplishments during past year All the redwood volume and taper tables, and explanation of use and construction were mimeographed in one Station release in March, 1941.
7. Plans for next year None. Project completed.
8. Date of completion 1941.
9. Assignment Hallin.

January 1942

Planting - Establishment and Growth of Planted Redwood

1. Field division Forest Management Research - Redwood Region.
2. Work project Regeneration.
3. Line project Planting - establishment and growth of planted redwood.
4. Purpose Study of planting methods, survival and growth of redwood and associated species to determine best species and class of stock, and probable survival and growth.
5. Review of past work Results of commercial planting on 26,400 acres of redwood cut-over show average early survival of 36 percent varied widely with exposure, interval between logging and planting, and associated vegetation. Poor survival and growth, especially on southerly exposures, found on clear-cut severely burned areas. Recent damage and growth studies based on data from 1300 trees on 96 plots established 1937 show sustained loss of planted trees principally from fire and rodents. After 10 to 15 years of very slow average growth rate trees now showing marked acceleration of growth. Annual average height growth from time of planting (1925 to 1930) to 1937 only .53 feet. Average annual growth for period 1937 to 1940 .87 feet.
6. Accomplishments during past year The data from 1937, 1938 and 1940 examinations were studied using analysis of variance.
7. Plans for next year Preparation of progress report on results of analysis.
8. Date of completion Indefinite. Plots to be reexamined at 5-year intervals from 1945 on.
9. Assignment Person, Hallin.

January 1942

Behavior

1. Field division Forest Management Research
2. Work project Forest Fire Protection
3. Line project Behavior
4. Purpose To provide facts on the behavior of forest fires - information basic to solution of problems in the field of fire control through study of physical relationships between forest fire behavior phenomena and their pertinent variable and constant controlling factors. Subject-matter field includes identification and development of practical methods for measuring or estimating the magnitudes of the variables, as well as evaluation of their influences upon forest fires.
5. Review of past work Show in 1915-17, found rate of spread of surface ponderosa pine fires proportional to the square of the wind velocity. When organized fire behavior research was resumed in 1933, his data were augmented and spread estimates revised on basis of 300 test fires. Similar data pertaining to northern California brush type subsequently obtained on 33 brush test fires. These studies provided quantitative information on effects of wind and fuel moisture on fire spread for application in danger rating and indicated necessity for securing more adequate measures of all controlling variables. Xylene distillation method for determining moisture content developed for experimental purposes. Methods of sampling fuel moisture developed for pine and brush fuels. Studies of wind movement indicated proper methods for measuring wind in different forest covers. Study of seasonal variations in brush foliage indicated necessity for recognizing growth stage in rating fire danger; appropriate indices developed. Wind tunnel constructed and techniques for studying model scale fires developed. These studies have provided added information on surface rate of spread, and at the same time have indicated measures of fuels and fuel beds necessary for rate of spread type classification. Experimental techniques developed for studying fire ignition probability.
6. Accomplishments during past year Obtained continuous records of weather elements and fuel moistures in continuing study of weather and fuel moisture relationships. Developed thermopile and recording apparatus for obtaining litter temperature. Obtained continuous wind records at six sites in study aimed at standardization of wind instrument exposures for fire danger rating purposes. One hundred additional tests of fire ignition made in wind tunnel indicated important effects of wind, moisture content, and fuel bed on probability of ignition by cigarettes. Eighty-five model scale fires in a wind tunnel with fuel beds of dead twigs substantiated trends in fire spread predicated theoretically in fuels of varying size and arrangement.

Current contributions made to the basic theories of combustion and of fuel moisture variations. In cooperation with Weather Bureau and Massachusetts Institute of Technology completed a study of meteorological aspects of lightning-caused forest fires. Secured seasonal data on foliage variations in a number of southern California chaparral species comparable to work previously done in the north.

7. Plans for next year To continue intensive study of each of recognized variables controlling fire behavior to the end that they may be properly sampled and measured for experimental purposes and for practical application in prediction of fire rates of spread and fire danger. Emphasis will continue on evaluation of fuel variable in view of extreme need for fuel type classification. Evaluation of combined effects of these variables on fire behavior will be continued through study of model scale and field fires.
8. Date of completion Indefinite.
9. Assignment Buck, Fons.

January 1942

Control

1. Field division Forest Management Research.
2. Work project Forest fire protection.
3. Line project Control.
4. Purpose To devise cheaper and more effective methods of forest fire protection. Adequate and continuous fire protection is absolutely essential to full and perpetual use of all resources on forest land. In some areas new and more effective methods of fire protection are needed. In all sections possibility of devising cheaper but equally effective methods should offer promising opportunities to reduce annual costs. Past experience and personal judgment have played a major role in fire control development thus far. The objective of systematic fire control research is to supplement this experience and judgment, not to replace it.
5. Review of past work Results of past work are largely expressed in eight departmental bulletins and circulars, and numerous shorter publications, establishing principles governing intensity of fire control facilities and methods of arriving at most effective placement of facilities. Basic fire control plans for the California national forests are built upon these principles. Principles governing forest fire detection, effectiveness of lookouts, and methods of planning organized detection developed through analysis of records and field study. Methods of controlling inflammable vegetation developed for economical firebreak maintenance and reduction of roadside hazard. Fire danger rating system developed for state-wide application. Data secured on rate of fireline construction in California cover types. New principles of overhead organization for suppression of large fires given detailed study and field trial. Preliminary laboratory studies of wetting agents and of fire suppressing chemicals undertaken.
6. Accomplishments during past year Collaborated with Region in preparation of manuscript on desirable size of suppression crews. Completed study of detection problem on the Angeles National Forest. Completed preliminary report on past fire history of Angeles National Forest. Completed field experiments in study of visibility of test smokes by lookout observers. Developed method of integrating seasonal influence of herbaceous vegetation on fire danger and incorporated same in rating system.

7. Plans for next year

- a. Continue study of use of water and chemicals in fire suppression.
- b. Investigate herbicidal characteristics of boric acid-borax mixtures.
- c. Complete analysis of atmospheric haze and test smoke visibility.
- d. Complete long-term research work program for the southern California forests.
- e. Complete report on southern California fire history.
- f. Continue study of organization management in the control of large fires.

8. Date of completion

Complete analysis of smoke visibility, southern California work program and report on southern California fire history in 1942. Remainder indefinite.

9. Assignments

Buck, Bruce, Abell.

January 1942

Segregation

1. Field division Forest Management Research.
2. Work project Forest Genetics.
3. Line project Segregation - the selection of best forms for use in forestry.
4. Purpose To select races, strains and individuals of ponderosa pine of unusually rapid growth rate for use in forest planting operations. To seek methods for selecting the most desirable trees to be saved during logging operations for natural re-seeding of the cut-over area. This problem is approached through the use of morphological, physiological, cytological and statistical techniques.
5. Review of past work Progeny tests started in 1929, 1937 and 1939 indicate existence of heritable differences of growth rate among geographic races, elevational strains and individual trees. Eddy Arboretum, including some 90 of the species and varieties of pine, assembled for breeding stock. Breeding stock of several of the geographic races of ponderosa pine represented in the arboretum. Behavior of these races demonstrates their genetic distribution, emphasizing the possibility that among the possible crosses between these races heterosis or true hybrid vigor may be found.
6. Accomplishments during past year Measurements and photographs of the progeny tests taken. Each year these records add to reliability of the tests and work based on them. The 1929 test of geographic races was thinned, more than half of the 1200 trees being removed. One criterion for thinning was resin midge injury. During the operation it was learned that certain races and certain progenies resisted attack by resin midge. A manuscript based on these findings is nearing completion. This work opens the field of breeding and selecting strains of ponderosa pine resistant to this insect, and in addition furnishes a criterion by which highly susceptible seedlings may be removed from the nursery.

Biochemical methods were developed for identifying aberrant individuals and for classifying intermediate hybrid forms. A report on the work is now ready to submit for publication.

The heritability of branching angle was studied in the progenies of 4 trees, the results to appear in a paper nearing completion. This is one of the studies designed to furnish information needed in the selection of trees to be left for reseeded an area that is to be logged.

The parent trees used for past progeny tests were classified on basis of performance of their progenies. Seeds of these trees were furnished Mr. Dunning for his research plantings, and the remainder will be made available to the regional planting officer.

A few years ago Professor Ashby found a correlation between embryo size and growth rate in his experimental plants. The possibility of selecting seed that would produce vigorous trees was of such importance that the method was checked using two pine species. Results were negative with pine, but the study demonstrates how the most promising lead in research may often prove fruitless - but should nevertheless be explored.

7. Plans for next year Of high priority is field testing of selected and hybrid material that has performed well in nursery and arboretum tests. This work ties in with any prospective post-war planting program.

The work on hormone and chemical analysis should be intensified as it offers one of the most promising leads for detecting superior trees in the forest, to be used as a seed source for both natural and artificial reforestation. The studies of inheritance of such characters as spiral grain and branching angle have the same objective and should be accelerated for the same reasons.

Routine care and analysis of data of the progeny tests should continue, to preserve continuity and furnish information for further selections.

8. Date of completion Continuous.
9. Assignment Austin, Weidman, Mirov, Stockwell, Liddicoet.

January 1942

Breeding

1. Field division Forest Management Research.
2. Work project Forest Genetics.
3. Line project Breeding - the production of new forms of pine.
4. Purpose To shorten the cutting cycle or increase the yield of pine forests by the use of all the special techniques that can be brought to bear on the problem. Effort will be directed primarily to producing new kinds of pine trees under controlled conditions, and to collecting the occasional new forms that occur in nature. Such trees include hybrids both natural and artificial, mutations, polyploids and other new forms that appear occasionally in nature or that can be produced in the laboratory by the use of heat, pressure, centrifugal force, x-rays, monochromatic light rays, chemical treatment, and complex crossing procedures. This work presupposes the use of morphology, cytology and physiology in the detection and study of these tree forms.
5. Review of past work Past effort directed to breeding pines, particularly ponderosa pine. Satisfactory, but not perfect, techniques and equipment developed after considerable testing and selection of known methods for observing and protecting conelets and maturing cones; collecting, storing and applying pollen; applying physical and chemical treatments to plants; examining and testing new forms morphologically, cytologically and physiologically. A good collection of pine species, including numerous natural mutants and hybrids, has now been assembled. From the numerous crosses that have been attempted (3764 ovulate flowers were pollinated in 1941) 14 hybrid populations have resulted directly, but of more importance is the information derived on relationships and possibilities in the field of pine hybridization. Numerous mutations produced by chemical treatment, and the effects of dosage on various plant organs has been checked. Studies of morphology and flower structure and habit have aided in planning crosses in advance and in applying the various chemical and physical treatments.
6. Accomplishments during past year Improvements and tests of reliability of techniques used in major lines of work were made. Approximately 600 mutations or new forms resulting from colchicine treatment segregated for study. Eighteen pairs of twin seedlings examined cytologically for chromosome aberrations, but none found. First seeds collected of the hybrid Coulter x Jeffrey.

First seeds collected of the attempts started in 1940 to cross yellow pine (ponderosa) with white pine (Balfouriana). Natural hybrids between Monterey and bishop pines were found. Of the artificial hybrids

appearing in the seedbed, the cross between eastern and western white pine, and the cross between jack pine and lodgepole pine showed an increased growth rate - perhaps 25 percent.

In 1941 controlled pollination between species was directed to the combining of characters with rather definite specifications in mind. Pollinations were made at the request of Dr. Haig to produce a quantity of seed of P. rigida x P. taeda for use in the New Jersey pine barren area. Because only 400 flowers capable of yielding a dozen seeds each of rigida were available for this cross, 800 available flowers of P. echinata were pollinated with rigida pollen. Pollinations between the Sierra ponderosa and the hardy scopulorum form of Colorado were made for possible use in the eastside, the intermountain and the Rocky Mountain regions. Pollinations between several geographic races of ponderosa pine were made because, genetically, this intra-specific crossing program offers the greatest possibility for securing marked hybrid vigor. Plans are being formulated for the introduction and maintenance of rapid growing or otherwise desirable trees in the field planting program of the region.

7. Plans for next year It is planned to reduce the work with species hybrids and to concentrate the necessarily reduced effort (a 400 to 700 bag program) on crossing varieties and geographic races of ponderosa pine. In addition to the objective of securing hybrid vigor, this work will be pointed toward the presently more important production of strains suitable for replanting deforested areas of the region.
8. Date of completion Continuous.
9. Assignment Righter, Stockwell, Mirov, Cumming.

January 1942

Propagation

1. Field division Forest Management Research.
2. Work project Forest Genetics.
3. Line project Propagation.
4. Purpose To test known and new methods of propagating forest trees that may be needed in the prosecution of the genetics research program, and to search particularly for better or cheaper methods of propagating trees in the forest, either by planting or by encouraging or controlling natural re-seeding.
5. Review of past work Nursery techniques suitable for the production of experimental material worked out. From the possible methods of grafting and budding trees those that could be adapted to propagating pine were selected. It was determined that pines could be grown in nutrient culture medium (water culture).
6. Accomplishments during past year A limited study of the water requirements of out-planted nursery stock at Placerville was completed, the results of which are being prepared for publication. A related study dealing with the water-holding capacity, wilting point and water loss of the soil was finished and discussed in an office report. These tests were designed and carried out to furnish information on when and how much water must be applied to outplanted experimental trees to insure survival and normal growth.

Completion of the greenhouse made possible the start of a new phase of rooting pine cuttings to learn the most favorable season and the best moisture conditions for this work.

A few trees produced in and outplanted from water culture tanks suffered little or no transplanting shock and gave higher survival than nursery dug trees. It is believed that this was due to their outstanding vigor resulting from optimum growth conditions and to the fact that their root systems were uninjured by digging. It seems likely that this method will be most valuable in removing the variable of transplanting shock to outplanted experimental trees. Transplanting injury and consequent shock is greater to some trees than to others. This unavoidable result of digging trees from the soil for outplanting tends to cloud results of competitive growth tests for many years. If cost per survived tree in the field can be reduced sufficiently the method would have certain advantages for regular forest nursery practice.

It has been learned that delicate, frost susceptible, and slow-growing species of pine can often be maintained more easily or made to grow faster by grafting the species on native ponderosa pine stock.

7. Plans for next year It is planned to collect and report on all water relations data on hand.

Further work on the water culture method is planned, with emphasis on reducing cost of production, and checking survival value of trees so produced.

Work on relation between stock and cion will be continued, with ponderosa pine to induce early flowering, and with other species to preserve certain delicate breeding material.

8. Date of completion Continuous. Each test will be reported as finished - but new problems in this field arise each year.

9. Assignment Mirov, Weidman, Stockwell, Liddicoet.

January 1942

Species-Survival Testing of Range Forage Plants

1. Field division Range Research.
2. Work project Artificial revegetation.
3. Line project Species.
4. Purpose To find species that are suitable for planting on California foothill and mountain ranges, and to determine the best means of getting them established.

Foothill Ranges

5. Review of past work Limited nursery row-survival tests started in 1934 at the San Joaquin Experimental Range. Total species or strains tested to date: 225, furnished primarily by Bureau of Plant Industry. Several species proved to be adapted in the nursery under cultivation, some outstanding ones being subterranean clover, bur clovers, wimmera ryegrass, shadscales, garden burnet, rhizomatous alfalfa, smilo, and Harding grass. Of the promising species planted in ungrazed competition plots, only garden burnet and ryegrass continued to produce seed. Limited phosphate fertilizer tests showed little effect on clover.
6. Accomplishments Completed observations on present nursery rows.
 during past year Several species in field plots were observed during first year of competition with aggressive annuals; including plots under limited clipping and grazing treatments. Smilo, Harding grass, rhizomatous alfalfa, and wimmera ryegrass showed up well, especially under grazing, although the alfalfa made less growth than expected. Limited early spring tests indicate practical possibilities for establishment of smilo both by vegetative means and by seed. New alfalfa plots proved especially vulnerable to grasshopper attack. No species has been carried far enough to warrant recommending for extensive planting on the range.

Revised general working plan, reorganized nursery, planted 102 new rows including Bureau of Plant Industry uniform strain tests, planted 35 species in broadcast competition plots, and started field plot test on fertilization of subterranean clover and bur clovers.

7. Plans for next year Start new row observations in nursery, establish permanent plots for routine broadcast competition tests of promising species. Make cooperative tests of broadcast mixtures at different elevations on different sites but continue to confine the limited project to the granite area. If possible, intensify strain and soil treatment tests of subterranean clover and bur clovers, make propagation tests of most promising species, especially smilo, and establish competition-site-treatment tests for a few most promising species.

8. Date of completion Continuing project as necessary part of the revegetation program.

9. Assignment Talbot, Bentley

Mountain Ranges

5. Review of past work Two areas reseeded several years ago by the Lassen National Forest, examined in 1940 as an aid in planning future reseeding experiments. The Dry Lake Area, fenced in 1933 and planted to crested wheat and smooth brome in 1934 by broadcasting and harrowing, resulted in only 5-percent establishment. Several native grasses increased on these areas both through the enlargement of existing plants and by the establishment of reproduction. Individual plants of the sown species, also increased in size. However, no signs of reproduction from seed were observed in the 7-year elapsed time from planting. The Norvel Flat Area treated in essentially the same manner as the Dry Lake Area, showed much the same results. Here, however, many of the native species became established directly in the harrow furrows made while planting the purchased seed. In some places solid lines of native Poas and Stipas became established. This harrowing aided the establishment of native species to such an extent in this case that it was thought advisable to scarify 4 plots during 1941 to see if further establishment of seedlings — native and introduced — could be induced.

6. Accomplishments during past year Scarified plots at Dry Lake and Norvel Flat were examined. No establishment of crested wheat or smooth brome seedlings was found. A few seedlings of Stipa occidentalis germinated, but range improvement was negligible.

7. Plans for next year If time is available will examine additional reseeded areas in the eastside region for the values they may have for research or actual reseeding—facts particularly needed for anticipated post-war programs.

8. Date of completion Examination of areas reseeded by eastside forests to be completed in 1942.

9. Assignment Talbot, Hornay.

January 1942

Methods of Managing Foothill Ranges

1. Field division Range Research.
2. Work project Grazing management.
3. Line project Foothill ranges.
4. Purpose Broadly, to determine effect of degree and season of grazing on the forage and the grazing animal, and to improve yardsticks, or standards, which will make possible recognition and definition of most profitable and continuing range use. More specifically, to determine the composition, growth, seasonal values and yearly changes in the annual forage type as effected by weather conditions, site and treatment.
5. Review of past work Annual inventories of forage, continuous records of climate and periodic records of seasonal growth made since 1935 at San Joaquin Experimental Range. University of California cooperators have made chemical analyses of most important species and vegetative and chemical analyses of forage eaten by cattle. Six pastures (2 small, 2 medium-sized, and 2 large) established in 1935; since 1937 stocked from January to August with a cattle breeding herd at approximately 9, 14 and 18 acres per animal unit for 7 months. Cattle spend remainder of year in holding pastures where one-half are supplemented. Cattle gains and forage growth and utilization in pastures are measured.

About 99 percent of herbaceous forage cover on experimental range composed of annuals; 60 percent introduced species. Broadleaf alfalfa, soft chess and foxtail fescue make up over half of forage crop; first two most important species. Perennial grasses unimportant and have not increased under management. Perennial rushes are sparse but furnish considerable forage for limited time after other species dry. Yearly growth periods of forage: (1) Germination (usually in October) and slow winter growth; cannot expect sufficient feed for stock during all of this period. (2) Rapid growth and abundant forage from latter February or March through April. (3) Rapid drying during May and June and deficient ration until growth of new crop. Browse furnishes little forage but may take care of vitamin A requirements during dry season. Extreme yearly fluctuations expected in this type of forage crop make it necessary that the stockmen keep business extremely flexible.

Forage inventories of entire pastures have not shown definite relationships between rates of grazing pastures for 7-month season and trends in forage density and composition — less reaction to extremes than expected in most types. Grazing seasons of different length might yield different results. Longer cumulative effects of close grazing not known; no drought years yet. Complete protection results in forage deterioration which may be rapid on good sites where litter accumulates rapidly. New feed on moderately or lightly used areas is 2 or 3 weeks earlier (at time when badly needed) than on closely used areas. Pounds gained per animal unit have been less in very closely grazed areas and cattle have shown other differences due to lack of sufficient forage.

Galley proof of interagency manuscript to be published as a University bulletin, expected daily.

6. Accomplishments during past year Experiment continued. Heavy late rains resulted in a long green-feed period and lighter than average utilization. Measurements made in 6 large temporary exclosures moved each year along the fenceline between a closely grazed and a lightly grazed pasture for the second year failed to show significant forage differences between pastures—except for earlier forage in lightly grazed area.

Field work concentrated on measurement of variables causing differences in forage production and utilization between pastures of equal size. Different types of range in the pastures were defined and mapped and the amount of non-grazable area in each determined by field survey. Analysis of the variables started with assistance of Statistical Laboratory of the University of California.

7. Plans for next year Continue grazing experiment. Measure as closely as possible the factors which analysis to date has shown need quantitative expression. Run pilot test on measurement of yield, by use of portable protected plots. Prepare working plan to include modifications which the analysis indicates as necessary. Prepare, in cooperation with Region 5 and Agricultural Adjustment Administration, utilization standards for the annual type to be used by Agricultural Adjustment Administration compliance examiners.
8. Date of completion A continuing project.
9. Assignment Talbot, Bentley, Nelson.

January 1942

Effect of Grazing on Surface Run-off, Erosion and
Infiltration Capacity - Foothill Ranges
(In cooperation with Division of Forest Influences)

1. Field division Range Research.
2. Work project Grazing management.
3. Line project Effect of grazing on surface run-off, erosion, and infiltration capacity.
4. Purpose To determine effect of different intensities of grazing on (1) surface water run-off, (2) soil erosion, and (3) infiltration. Highly important to know whether, and to what degree, soil erosion is reducing productive capacity of granite soils. In addition, there is increasing demand for data on water production and floods. Run-off and infiltration data obtained from these plots will also have bearing on these problems.
5. Review of past work Installation consisting of 3 triplicate sets of 1/40-acre plots established in 1934 on San Joaquin Experimental Range. Until March 1938 cover on plots was undisturbed. During this calibration period there was no erosion, and surface run-off was less than 1 percent of precipitation, indicating an infiltration capacity of soil under ungrazed forage cover equal to or in excess of the highest rainfall intensities occurring during that period. Surface run-off from these plots should not be confused with total water yield, which would include percolation.

Since March 18, 1938, 3 plots grazed heavily (by sheep), 3 moderately, and 3 ungrazed as checks. Closely grazed plot almost bare of litter; protected plot has litter at least 1/2-inch deep. Erodium botrys, Bromus mollis, and Festuca megalura make up most of the vegetation on these plots. One of biggest changes in composition has been an increase in Calandrinia on the grazed plots; it increased most on those most closely used. In spite of very heavy grazing no appreciable increase in run-off has taken place.

Infiltration tests during summer of 1940 showed that moderate grazing has brought about significant reductions in the infiltration capacity of the soil on the plots, and that under heavy grazing, reductions are highly significant. For example, the mean infiltration capacity, with soil at field-moisture capacity, was: ungrazed plots, 8.0 inches per hour, moderately grazed, 5.8; and closely grazed, 3.4. There was a direct relationship between intensity of grazing and reduction of infiltration capacity of the soil; however, the mean capacity even under close grazing was still above the rainfall intensities which occurred on these plots, except for a few peaks of very short duration.

6. Accomplishments
during past year Plots grazed as in past but intensities of utilization were somewhat lower. Grazing increased run-off under higher rainfall intensities, the ratio of increase over the ungrazed plot being 160 for heavy grazing and 6 for moderate grazing, but total run-off is still less than one percent of the total seasonal rainfall.
7. Plans for next year Continue grazing as in the past.
8. Date of completion Probably graze the plots at above rates for at least 2 more years, to build up any effects from continued heavy grazing, to obtain a better representation of total amount and seasonal distribution of precipitation, and if possible to measure the effects from the very high intensities of rainfall which occasionally occur - intensities higher than any that have occurred to date on these plots.
9. Assignment Talbot, Bentley (Range Division).
Kraebel, Rowe (Influences Division).

January 1942

Ponderosa Pine Ranges

1. Field division Range Research.
2. Work project Grazing Management.
3. Line project Ponderosa Pine Ranges.
4. Purpose To determine the seasonal value of cut-over pine and other range types, and to obtain other supporting information on the value and use of these types for grazing by livestock.
5. Review of past work Experiments in the Burgess Spring Experimental Pasture have yielded results which form a basis for determining the best season of use of cut-over pine lands in terms of livestock weights.

Festuca idahoensis, Lupinus calcaratus, Sitanion hystrix, Purshia tridentata, and Bromus marginatus made up the bulk of the forage eaten.

Weights taken at 2-week intervals during the grazing period for 3 years showed (1) cattle made greatest gains early in the grazing season before the key forage species flowered (2) daily gains declined steadily from June to September, and (3) cattle lost weight after forage matured and dried. Weight losses were not due to lack of forage but rather to nutritional deficiencies after the middle of September. Data give a basis for determining best season of use of cut-over pine type, and show that the forage has greatest nutritional value early in season. Early season of use of forage indicated, providing it can be maintained.

Studies have been carried on in the past on the effect of livestock grazing on tree reproduction. Results have shown that this is not a serious regional problem. However, the effect of grazing on first-year seedlings was not easily tied down and investigations have been continuing along these lines. Recent measurements were made on the Modoc National Forest, on grazing effects on pine seedlings established through the preparation of a favorable seedbed under the trees by artificial scarification.

One of the most important forage plants on eastside ranges is bitterbrush—the most important browse species. It is so important in management that special attention has been given it in an observational way for some time. Since many bitterbrush stands are in a deteriorated condition and reproduction has been found to be lacking in many areas attention has been directed to its utilization and method of reproduction.

6. Accomplishments during past year Plans were prepared for the expansion of the season-of-use studies at Burgess Spring to include meadow lands which are generally used in conjunction with cut-over timber types on eastside national forests. These plans were approved by Washington and necessary construction was started. Past research at Burgess Spring was analyzed further for inclusion in an analysis of range problems of northeastern California, which has been completed and is being mimeographed.

The establishment of pine seedlings on the scarified areas on the Modoc National Forest were recorded on 24 transects. The favorable effect of scarification was clearly evident in the greater number of seedlings germinating and surviving the first year on the scarified areas.

The heavy utilization of bitterbrush by deer during the winter was measured on 5 plots. Additional plots were laid out in the fall for recording the utilization during the winter of 1941-42. Measurements taken during the summer showed that rodents were very important in the establishment of bitterbrush reproduction, also that soil scarification favored the germination of bitterbrush seed and the establishment of seedlings.

7. Plans for next year Publish results of past research at Burgess Spring. Complete necessary construction for expansion of Burgess Spring project. Continue limited measurements on important factors in the life history of bitterbrush. Continue limited observations and measurements on the effect of livestock grazing on tree reproduction.
8. Date of completion Indefinite.
9. Assignment Talbot, Hornay.

January 1942

Logging and Milling Studies
in California Pine Region

1. Field division Forest Products.
2. Work project Timber harvesting and conversion.
3. Line project Logging and milling - pine region.
4. Purpose To correlate quality, in terms of log and tree grades, with lumber realization values and to analyze production costs of logs and trees from stump to lumber shipment. Studies designed to produce results which constitute economic bases for forest management and are applicable and in demand for (1) timber stand appraisals, (2) economic comparisons of forest practices, (3) determination of economic utilization limits for trees and logs, and (4) sale of logs on a quality basis. Project confined to problems peculiar to pine region.
5. Review of past work Work initiated in 1929 with comprehensive logging and milling study of western Sierra, Site I timber. Two special mill studies of white fir yielded information on recovery values and seasoning degrade data and furnished a basis for revision of Forest Service scaling practice for this species. A logging and milling study of eastern Sierra pine, Sites III and IV, resulted in an improvement in marking practice by the cooperating company and provided stand evaluation data for management research on the Blacks Mountain Experimental Forest. A mill study confined to small trees of ponderosa pine, Site II, furnished lumber realization values for trees and logs that occur infrequently in stand-run studies, and disclosed significant variations in seasoning and surfacing degrade of pine lumber. A mill study of insect-infested trees showed rapid deterioration of lumber value due to blue stain and contributed to new method of attack on the bug-tree problem at Blacks Mountain Experimental Forest. A mill study of western Sierra, Sites II and III timber augmented the timber appraisal data of the region to cover these sites. The first of a series of mill studies for evaluation of tree classes of Blacks Mountain Experimental Forest indicated that there may be a value differential between trees of different insect risk classes; the results were not conclusive.

All pine mill studies have contributed to the evolution of a log grading system for ponderosa pine in California. This Station participated in construction of proposed "standard log grades" for ponderosa pine. The application of these new specifications in re-analysis of some of our past pine studies has shown grades to be in need of adjustment. Experience in problems of logging and milling studies has resulted in publication of "Part I, Field procedure, manual of field and office procedure for logging and milling studies in the California pine region". The results of eastside pine studies

have been carried directly into Forest Management research by cooperation of this Division in log grading all trees on experimental cutting plots at Blacks Mountain Experimental Forest.

6. Accomplishments during past year Field work on mill study of 47 second-growth ponderosa pine trees was completed. Preliminary analysis has shown that log grades developed for old-growth pine are not adequate for second-growth and that three relatively simple grades for second-growth logs may be defined. A mill study of pond-run logs of westside ponderosa pine and sugar pine embracing 470 M board feet was executed. The study was designed to compare pine log grades developed by this Station with the proposed "standard log grades" and with a third system proposed by Region 5 logging engineer. Results of study will be put to immediate use by Region 5 Office of Private Forestry in an economic study of area from which logs were taken. Routine log-grading of trees on 1941 cutting plots of Blacks Mountain Experimental Forest was carried out. Field work was initiated on study of logging costs in two methods of cutting at Blacks Mountain Experimental Forest in cooperation with Division of Pine Management.
7. Plans for next year Complete analysis and report on second-growth mill study. Complete analysis and report of westside ponderosa pine and sugar pine study. Handle routine log grading of 1942 cutting plots at Blacks Mountain Experimental Forest. Make preliminary analysis of yarding time study of methods of cutting at Blacks Mountain Experimental Forest; augment field data. Conduct mill study of trees of different insect risk classes (depending upon effect of war on cutting practice of cooperating mill).
8. Date of completion Continuing project.
9. Assignment Garland.

January 1942

Logging and Milling Studies in California Redwood

1. Field division Forest Products.
2. Work project Timber harvesting and conversion.
3. Line project Logging and milling - redwood region.
4. Purpose To correlate quality, in terms of log and tree grades, with lumber realization values and to analyse production costs of logs and trees from the stump to lumber shipment. Studies are designed to produce results which constitute economic bases for forest management and are applicable for (1) timber stand appraisals, (2) economic comparisons of forest practices, (3) determination of economic utilization limits for trees and logs, (4) sale of logs on a quality basis, and (5) scaling of logs with formal methods of cull deduction. This project confined to problems peculiar to the redwood region.
5. Review of past work This project was begun with a logging and milling study of logs from a 79-acre plot of Humboldt County redwood in cooperation with the Division of Redwood Management in 1935. Log grade specifications for this study were formulated from general advice from experienced redwood men. The realization values of these grades were published as a preliminary mimeographed report. A further mill study of smaller logs was conducted in Humboldt County in 1936. The log description and lumber production data from both studies formed a basis for a revision of log grade specifications for redwood which were published with lumber grade production and value data in 1936. Logging cost data were combined with results of above mill studies and a mimeographed report issued showing tree diameter limits for greatest net annual returns and greatest net return per acre.
6. Accomplishments during past year A mill study of 150 redwood logs from Humboldt County was conducted, analyzed and reported (not for publication). The specific objective was to test log grades that had been formulated from earlier studies. Results showed that the grades are suitable for use in Humboldt County timber. Analysis was made of cull deductions in order to encourage the improvement of log scaling practice in the redwood region. Results of the study were put to immediate use by the Region 5 Office of Private Forestry, in an economic study of an area owned by the cooperating company.

7. Plans for next year Publication of results of 1941 study.
Execution of a mill study in Mendocino County
redwood which is recognized as different timber than that of Humboldt
County.
8. Date of completion Continuing project.
9. Assignment Garland.

January 1942

Timber Conversion - Utilization

1. Field division Forest Products.
2. Work project Timber harvesting and conversion.
3. Line project Utilization - species and products.
(Use development: changes in material usage).
4. Purpose To promote proper utilization of various species and products through study of their properties, form and quality, and supply as related to use requirements. To connect requirements of a war economy with latent resources of California forests. To provide field cooperation for work of Forest Products Laboratory.
5. Review of past work Cooperated with Forest Products Laboratory in a comprehensive study of utilization of white fir; results published in a Government bulletin, 1934. Informal investigation of use of white fir in the box industry in 1940 showed that some of the inferiority of the wood in this trade may be attributed to inadequate seasoning. Preliminary investigation made of wood-using industries in the Los Angeles area by Erickson has shown that there are many uses for which some hitherto non-commercial California hardwoods might well be adapted.
6. Accomplishments during past year In cooperation with the Forest Survey Division an investigation has been made of sources of supply and characteristics of manzanita burl for smoking pipes. A manuscript has been prepared for a mimeographed research note outlining the distribution of burl-forming manzanita, the history and economics of the pipe block industry, the extent of the domestic industry, and the possibilities of manzanita pipe block production. Study of the seasoning properties of California chinquapin lumber by the Forest Products Laboratory was initiated. Technical consultation was given on the following local utilization problems: tannin sources, adaptation of a patented fruit drying process to lumber, production of Port Orford cedar battery separator plates, cork substitutes, lumber grade specifications for California Douglas fir lumber.
7. Plans for next year Utilization problems connected with the war effort will be given precedence over all other work of the Division. Study of manzanita and other California species for smoking pipes will be continued. Study will be made of possible California substitutes for cork in cooperation with the Forest Products Laboratory and a local linoleum plant.
8. Date of completion Continuing project.
9. Assignment Garland.

Experimental Inventory

1. Field division Forest Survey.
2. Work project Survey of forest resources.
3. Line project Experimental inventory.
4. Purpose To develop a plan for conducting a regional timber volume inventory to determine the quantity, kinds, quality, and availability of the standing timber together with the rate of growth and depletion.
5. Review of past work Field work on an experimental line-plot survey of Bidwell Bar Quadrangle (500,000 acres of timber) completed and timber volumes calculated. Techniques developed for classifying density of stocking and age-class structure of timber and cordwood stands; later reoriented to take full advantage of available aerial photographs. Preliminary plan for regionwide inventory partially completed. Detailed plan under way for 9,000,000-acre section postponed pending re-orientation of aerial-photograph classifications and determination of approved sampling procedures.
6. Accomplishments during past year Reoriented classification of density, age classes, and stand structure of timber and cordwood stands from aerial photographs following statewide field tests. Nearly completed Part 1 of inventory plan covering basic classifications of timber and cordwood stands.
7. Plans for next year Complete Part 1 of inventory plan and proceed with Part 2 covering sampling procedures as rapidly as circumstances require. Initiate survey if funds for that purpose are allotted.
8. Date of completion Indefinite.
9. Assignment Wieslander, Jensen, Burks, Wilson.

January 1942

Vegetation Type and Forest Condition Maps

1. Field division Forest Survey.
2. Work project Survey of wild-land resources.
3. Line project Vegetation type and forest condition maps.
4. Purpose To prepare:
 - (a) For 72 million acres of wild lands in California and western Nevada; vegetation type maps providing basic data for land-use studies and policies, for rating fire hazard and planning fire control, and for application of research pertaining to many phases of wild-land management.
 - (b) For forest and potential forest lands; supplementary maps providing information on present stand conditions and productive capacities for inventory purposes and forest-development plans.
5. Review of past work Reconnaissance survey begun in 1926, providing basis for compiling natural cover and land-use map of California in 1934. Subsequent intensive mapping has been widely used by Forest Service and other governmental agencies, county planners, and research groups. 45 percent of the field mapping and 37 percent of the office compilations completed to date. Under (a), 21 map units (9 percent) are published, 12 (5 percent) in process of publication, and 182 (38 percent) available in simplified form as blue-line prints. Under (b), 54 map units are available as blue-line prints. Multilithed regional reports released for 1 group of counties, with 3 additional completed or under way. Several papers published describing mapping methods and new office procedures. New techniques and classifications developed for mapping vegetation from aerial photographs.
6. Accomplishments during past year Under (a), 1 map unit (1 percent) submitted for publication and 130 (27 percent) prepared for blue-line reproduction. Under (b), 16 map units prepared for blue-line reproduction. Reoriented classifications of vegetation types and forest conditions following statewide field tests of the information obtainable from aerial photographs.
7. Plans for next year Continue type-map publication program as funds permit. Complete blue-line print preparation for remaining map units covered by field surveys. Complete illustrative folio of aerial-photograph classifications.
8. Date of completion Continuing project.
9. Assignment Wieslander, Jensen, Burks, Wilson.

January 1942

Ecological Studies

1. Field division Forest Survey.
2. Work project Survey of wild-land resources.
3. Line project Ecological studies.
4. Purpose To interpret the information presented on vegetation type maps, pointing the way to their usefulness for land-use planning, soil surveys, and other purposes.
5. Review of past work Mainly ground work data compilation for later analyses of correlations between present vegetational conditions and climate, soil, fire history, and land abuse, as follows:
 - (a) Southern California: 49 species distribution maps completed. Isohyetal map constructed, geological and fire history maps partially completed.
 - (b) Santa Cruz Mountains region: History of lumbering and its results compiled and published; fire history compiled; correlation between vegetation and soils for 23-mile transect analyzed and results showing index values of the vegetation prepared for publication.
 - (c) Statewide bibliographical research: 30,000 items on lumbering, fires, and vegetation abstracted. Items on lumbering history of Truckee River basin summarized for presentation in a paper.
6. Accomplishments during past year Under (b), analysis of the transect data carried out and written for publication; under (c), 7,000 items abstracted and indexed, exhausting all local sources, and Truckee River basin material summarized.
7. Plans for next year Under (c), complete Truckee River basin report and continue summarizations for other areas.
8. Date of completion Indefinite.
9. Assignment Wieslander, Jensen, Wilson.

January 1942

Herbarium

1. Field division Forest Survey.
2. Work project Survey of wild-land resources.
3. Line project Herbarium.
4. Purpose To preserve a collection of native plants
(a) authenticating the identification of all species recorded on the vegetation maps and sample plots and (b) providing information basic to many taxonomic, genetic, and ecological problems in the management of wild-land vegetation.
5. Review of past work 25,472 specimens determined, mounted, and catalogued; 906 sheets of a series showing distributions of important trees and shrubs compiled from type maps, sample plots and herbarium specimens; 5 papers published clarifying taxonomic problems and describing new species.
6. Accomplishments during past year Determined, mounted, and catalogued 86 specimens; checked 1,500 returns from specimens sent to Washington; and compiled the 906 sheets of distribution maps.
7. Plans for next year Continue research on difficult taxonomic groups; prepare simplified keys and charts for field identification; and continue compilation of species distribution maps.
8. Date of completion Continuing project for duration of vegetation type survey.
9. Assignment Wieslander, Burks.

January 1942

Financial Aspects — Sierra Nevada Forests

1. Field division Forest Economics.
2. Work project Private Forestry.
3. Line project Financial aspects.
4. Purpose To investigate the costs of, and returns from, scientific methods of management and utilization of Sierra Nevada forests to determine the economic practicability of forestry.
5. Review of past work Manuscript prepared describing western Sierra Nevada second-growth pine forests, their economic productivity, influence of tree size on costs and values, and indicating net returns of \$1.00 per acre annually from superior stands. Progress report completed on utilization conditions, markets, and prices and costs for second-growth lumber piling, mine poles, fuelwood, and veneer bolts.
6. Accomplishments during past year Manuscript approved for publication as California Agr. Exp. Sta. Bull. 658 "Factors affecting income from second-growth forests in the western Sierra Nevada", by H. R. Josephson. Utilization and marketing report revised and issued as Technical Note 14, "A preliminary survey of utilization conditions for second-growth timber products from the western Sierra Nevada."
7. Plans for next year Subject to prior requirements for immediate war research, plan for and initiate comparisons of the capital value and income return under alternative management plans of a selected pilot area of second-growth pine in the western Sierra Nevada in order to develop techniques of valuation and compare financial results of properly planned systems of liquidation and continuous production. Also cooperate to the extent possible in economic analysis of data from eastside pine. (Blacks Mountain.)
8. Date of completion Continuing project.
9. Assignment Crafts, in cooperation with Pine Management Division.

January 1942

Census of Manufactures: Logs, Lumber and Other Timber Products
(In cooperation with U. S. Bureau of the Census)

1. Field division Forest Economics.
2. Work project Forest products statistics.
3. Line project Forest products statistics.
4. Purpose To collect, edit, and record for the Bureau of the Census, data on the production of lumber, lath, shingles and other forest products; and for the Forest Service, data on stumpage prices, log prices, and lumber distribution.
5. Review of past work A standardized project repeated annually since establishment of the Station in 1926. Preliminary statements issued each year.
6. Accomplishments during past year Canvass made as usual. Preliminary statement of lumber, lath, and shingle production in 1940 released as Technical Note 15. Four special request compilations prepared, - two for the National Resources Planning Board, two for the Station.
7. Plans for next year Continue the "short form" type of Census. Complete 1941 canvass by March 1942 in order to facilitate planning production for war needs.
8. Date of completion Continuing project.
9. Assignment Crafts, Leonard, Garland, Person with other assistance as needed to meet the war deadline.

January 1942

Land Utilization

1. Field division Forest Economics.
2. Work project New public domain.
3. Line project New public domain.
4. Purpose To determine, (a) interrelationships among use of natural resources in northern Sierra Nevada, (cooperative project with Forest Survey and University of California), and (b) contributions of timber resources in Modoc County and comparison of sustained yield vs. liquidation for one segment of the county.
5. Review of past work Phase (a): Manuscript prepared showing essential interdependence of various land uses, and suggesting improvements through diversification of farming in orchard areas, range improvement and supplementation, developing forest for local income, preparation for declining return from mining, and adjustment of local governmental functions. Phase (b): None. Started in 1941 at request of Regional Forester.
6. Accomplishments during past year Phase (a): Manuscript submitted to Giannini Foundation for publication. Phase (b): Preliminary report prepared showing that one-fourth of all county workers are engaged in forest enterprises, forest income is one-third of total county income, forest taxes are 10 percent of total county receipts, contributions now are at peak and will decrease in future, and sustained yield preferable to liquidation when tested by resource productivity, population, and community quality, but not by test of incomes unless working circle enlarged or growth rate increased.
7. Plans for next year Phase (a): Manuscript revision and resubmission to University of California. To assist in necessary condensation, about 70 tables from the manuscript will be multilithed separately as a Forest Survey release, "Land utilization statistics for the northern Sierra Nevada." Phase (b): Preparation of final report, "Some social and economic effects of timber utilization and management in Modoc County, California."
8. Date of completion Phase (a): 1943; phase (b): 1942.
9. Assignment Wieslander, Crafts.
Weeks (Giannini Foundation), and Josephson
(Department of Forestry, University of California).

January 1942

Range Insurance

1. Field division Forest economics.
2. Work project Range economics.
3. Line project Range economics.
4. Purpose To appraise the possibilities and to develop a practical plan of range insurance that will protect the operator from severe losses in forage productivity and grazing capacity as a result of drought.
5. Review of past work Started in 1940. Insurance plan developed for Southwest, which aims to indemnify the insured for extra expense incurred as a result of extreme fluctuations in forage crop occasioned by drought. Such expenses are in form of purchase of feed, forced sales at low prices, or shipment of animals to distant pasture. Deficiencies in precipitation through their effect on forage production and grazing capacity are the actuarial basis for calculating indemnity. The policy planned is a valued one and the insured could get coverage from \$5 to \$25 per animal unit of grazing capacity.
6. Accomplishments during past year Plan developed to conclusion, report completed and accepted by University of Michigan in partial fulfillment of requirements for doctorate in Forest Economics. One-year term policy, based on grazing capacity and proper utilization, offers five types of coverage involving memorandum, deductible average, coinsurance and other clauses. Net rates computed at 61 localities average 3.32 percent of policy face value for all types of coverage, and gross rates vary from 2 to 10 percent. Since these are based on annual return rather than capital value, they compare favorably with rates in crop, rain, and livestock insurance. Government is recommended carrier for initial underwriting period. High social values evident because insured must practice good range management to get insurance.
7. Plans for next year Publication as bulletin by School of Forestry, University of Michigan. No further work by author required.
8. Date of completion 1942.
9. Assignment Crafts.

January 1942

Effects of War on Forest Industries

1. Field division Forest Economics.
2. Work project Effects of war.
3. Line project Effects of war.
4. Purpose A new project established "for the duration" to keep appraised of and supply information on, present and prospective demand for, and supply of, forest products and commodities necessary to their manufacture and use including labor and transportation.
5. Review of past work None. Started in 1941.
6. Accomplishments during past year Technical Note 16, "California forest statistics" (in cooperation with Forest Survey) which summarizes latest data on forest areas, timber stands, and lumber distribution and consumption. Technical Note 17, "Some economic facts about the California lumber and timber products industry and size of its dependent population," which shows that forest industries are among the foremost manufacturing enterprises, and their dependent population in 1939 was about 125,000. Manuscript, "Some effects of defense on wood utilization in California," for March Journal of Forestry which shows estimated 1941 lumber production at all-time high, 40 percent greater than average, and 17 percent greater than 1940, that employment was up 20 percent in 1941 and carloadings up 50 percent over 1939, and indicates possible shortages in plywood, seasoned lumber, containers, and machinery. Preparation of special request reports on boxes, battery separators, pencil slats, etc.; cooperation in the national wood-requirements survey.
7. Plans for next year To continue as needed by Washington and the field, analytical and fact-finding services through contacts with associations, producers, consumers and carriers in order to keep appraised of current situation, issue periodic activity reports, and act as clearing house for information relating to forest industries and the war in California. Consultation on post-war problems.
8. Date of completion When the war is won.
9. Assignment Crafts, with assistance as needed from other Divisions.

January 1942

Relation of Forest Cover to Streamflow
Kings River Branch - Teakettle Creek Unit
Fir-Pine

1. Field division Forest and Range Influences.
2. Work project Influence of natural vegetation on streamflow.
3. Line project Forest - relation of forest cover to streamflow.
Kings River Branch - Teakettle Creek Unit.
4. Purpose of work To study precipitation, run-off, ground-water, and erosion in relation to topography, geology, soil, vegetation and fauna in mountain areas by means of comparable watersheds typical of the southern Sierra in which precipitation is chiefly snow.

To determine methods of managing watersheds in representative fir and fir-pine types of Sierra Nevada (tributary to San Joaquin Valley) for maximum beneficial yield of water consistent with satisfactory control of floods and erosion and with other legitimate uses of the forest.
5. Review of past work Three 500-acre watersheds were selected in 1934 in headwaters of Teakettle Creek between elevations 6,000 to 8,000 feet. The area is tributary to North Fork of Kings River, Sierra National Forest, 75 miles from Fresno. Topographic map completed in 1935 and geological study including map and report in 1936. Facilitating improvements completed include 4 streamgaging stations with dams for erosion measurements, 3 shelter cabins, 1 warehouse, 8 miles roads, 2 miles telephone lines, 25 miles of trails (including 15 snow courses) and a domestic water system with 30,000 gallon reservoir. Collection of records started during 1939.
6. Accomplishments during past year Continued measurements of precipitation, air temperature and streamflow. Started measurements of snow-soil temperatures, and latent heat. Made eight surveys of the 15 snow courses. Observed changes in groundwater level in watershed 2A. Total precipitation for season 1940-41 at weather station No. 1 - 64.26 inches. Maximum depth of snow at main cabin - 91 inches.
7. Plans for next year Continue collection of data including periodic survey of snow courses if WPA assistance available.
If WPA not available project will be put in suspense status.
8. Date of completion Indefinite.
9. Assignment Kraebel, Sinclair, with technical assistance of other staff members as required.

January 1942

Relation of Forest Cover to Streamflow
Bass Lake Run-off and Erosion Plots

1. Field division Forest and Range Influences.
2. Work project Influence of natural vegetation on streamflow.
3. Line project Forest - relation of forest cover (second-growth ponderosa pine) to streamflow, Bass Lake run-off and erosion plots.
4. Purpose To study influences of second-growth ponderosa pine stands on surface run-off, erosion and water yield.
5. Review of past work Established in 1934; installation comprises six 1/40-acre plots, placed in triplicate in 60- to 80-year-old second-growth ponderosa pine stand, near Bass Lake, Sierra National Forest. All plots operated without disturbance of vegetation cover during calibration period first 4 years. On one set of three plots, ground cover of litter and herbaceous vegetation burned off annually since fall of 1938 to study effect of light ground fires on surface run-off and erosion. During calibration period and prior to burning of litter cover and herbaceous vegetation erosion was nil, and surface run-off from the plots averaged less than 1 percent of total precipitation. Since burning there has been a gradual increase in annual surface run-off, erosion has begun and has steadily accelerated.
6. Accomplishments during past year During the 1940-41 season there were 58.98 inches of precipitation. Approximately 11 percent of the precipitation ran off burned plots and produced soil erosion at rate of over 1-1/2 tons per acre. From undisturbed plots surface run-off was only about 0.3 percent of precipitation and there was no erosion. Needle fall from pines each year after burning has afforded fairly good ground cover before occurrence of first winter rains.

Run-off, erosion, and infiltration results of plot studies used by U.S.D.A. Flood Control Surveys in California in connection with hydrologic analyses. Precipitation intensity data published monthly by Hydrometeorological Unit of Weather Bureau.
7. Plans for next year Burning of ground cover on annually burned plots will be continued at least one more season. Treatment, consisting of simulated logging, conducted in accordance with standard logging practices of Region 5, will be started on undisturbed plots.
8. Date of completion Indefinite.
9. Assignment Kraebel, Rowe.

January 1942

Relation of Chaparral Cover to Streamflow
San Dimas Experimental Forest

1. Field division Forest and Range Influences.
2. Work project Influence of natural vegetation on streamflow.
3. Line project Chaparral - relation of chaparral cover to streamflow - San Dimas Experimental Forest.
4. Purpose To evaluate factors of precipitation, streamflow, ground water and erosion, and to study their relationship to topography, geology, soil, vegetation and fauna on certain watershed units in southern California.
To determine methods of watershed improvement and management in typical chaparral forest cover of southern California for maximum yield of useful water consistent with conservation and satisfactory control of floods and erosion.

5. Review of past work Initiated in 1932. Experimental area embraces 17,000 acres of San Dimas and Big Dalton drainages in Angeles National Forest tributary to San Gabriel River. Studies under way on 17 watersheds varying in size from 35 to 10,200 acres; each equipped with standard and recording rain gages, streamgaging stations, climatic stations, and reservoirs for measurement of erosion. Detailed surveys of vegetation, fauna and geology under way. Vegetative type maps and geologic maps of Bell and Fern Small Watersheds completed.

Publications: "Measurement of debris-laden streamflow with critical-depth flumes", by H. G. Wilm, J. S. Cotton and H. C. Storey. Trans. Amer. Soc. Civ. Eng., 1938. "An analysis of precipitation measurements on mountain watersheds", by H. G. Wilm, A. Z. Nelson and H. C. Storey, Monthly Weather Review, June 1939. "Topographic influences on precipitation" by H. C. Storey, Proc. Sixth Pacific Science Congress, Aug. 1939, vol. 4, pp. 985-993.

Manuscripts: "San Dimas streamgaging flume - a code for installation and operation", S. M. Munson, Karl J. Bermel and H. C. Storey, CF&RES Research Note No. 22.

6. Accomplishments during past year All research installations operated. Data tabulated and summarized through 1940-41 season.
Average seasonal precipitation by watersheds varied from 48.4 to 55.3 inches; streamflow for season ranged from 7 to 26 percent of precipitation.

The stream channel in Watershed X was mapped and the watershed boundary surveyed. Analysis of hydrologic data from this watershed has revealed that from 10.5 to 17.0 inches of rain must fall before ground water recharge begins. During period 1934 to 1940, inclusive, rainfall in stream channel of X accounted for all storm flow from all but seven storms. Curves show: (1) rate of ground water depletion,

(2) relationship between rate of discharge and volume of ground water in storage above streamgaging station, (3) relation between amount of rainfall and ground water recharge after initial recharge of season, providing no surface run-off occurs.

Soil depth measurements over the Forest indicate average depth of 14 inches with individual watershed averages ranging from 13 to 27 inches. This represents a volume of about 15,400 acre-feet of unquestioned soil material. In addition an unknown depth of fractured and decomposed rock beneath the soil mantle plays an important part in ground water storage and movement.

Soil moisture sampling at 13 different locations between elevations of 2000 and 5000 feet during past year indicates that about 3 to 5 inches of rain required per foot of soil depth to bring soil moisture to field capacity at beginning of rainy season.

Succession and phenological observations continued and plot data summarized to date. Herbarium increased to 590 sheets, vertebrate animal collection to 414 specimens, and seed collection to 408 species. A study of relation of deer population and habits to vegetation and soil disturbance continued in cooperation with Region 5.

Circulating flume for study of bedload effects upon rating of San Dimas flume completed and preliminary tests made. Some changes in design have been necessary to obtain uniform circulation of sand through the system. Work temporarily suspended.

During June 1941 a Civilian Public Service Camp for conscientious objectors to military duty was established at Tanbark. Ninety men now assigned to the camp have assisted in all phases of work on the Forest.

Major construction by CCC, CPS, and WPA:

1. Remodeled 5 large streamgaging stations.
2. Completed 4100-foot contour trail - 2 miles - in Wolfskill Canyon.
3. Installed new fire hose boxes at Tanbark.

Publications: "The sample plot as a method of quantitative analysis of chaparral vegetation in southern California" by J. S. Horton, Ecology, Oct. 1941.

Manuscripts: "Geology of the San Gabriel Mountains and its relation to water distribution" by H. C. Storey. "Handbook for field observers conducting watershed management research on the San Dimas Experimental Forest" by E. L. Hamilton.

7. Plans for next year Continue operation of installations and collection of data. Tabulate and summarize data to date. Continue analysis of hydrologic data from Watershed X and proceed with data for other watersheds. Continue vegetative, geologic and soils studies of the forest and surveys of watershed boundaries.

Continue study of influence of bedload on rating of San Dimas flume if personnel situation permits.

8. Date of completion Indefinite.

9. Assignment Kraebel, Sinclair, Storey, Hamilton, Colman.

January 1942

Relation of Chaparral Cover to Streamflow
Barranca Watershed

1. Field division Forest and Range Influences.
2. Work project Influence of natural revegetation on streamflow.
3. Line project Chaparral - relation of chaparral cover to streamflow - Barranca.
4. Purpose To study rainfall - run-off relationships and the development of chaparral during regrowth after fire; to test methods of measuring debris-laden flows.
5. Review of past work A debris-catchment reservoir, streamflow measuring equipment, 7 rain gages and 36 milacre quadrats were established on this 44-acre watershed in 1927, two years after denudation by fire. Weirs, Parshall flumes and tipping bucket installations proved inadequate as means of measuring flashy debris-laden run-off, yielded very incomplete records, and showed that some form of self-cleaning gaging device was imperative for measurement of such flows. Erosion deposits have been measured annually in reservoir. (See Relation of Forest, Brush and Grassland Cover and Management Practices to Erosion and Soil Stability, State-wide.)

A 3-foot San Dimas flume has provided a satisfactory record of streamflow since its installation in 1937.
6. Accomplishments during past year Rain gages and streamgaging stations maintained. Records tabulated and compiled. Deposit in reservoir resurveyed. Quadrat data summarized to date and analysis nearly completed for preparation of report upon regrowth of vegetation since 1926 fire. For erosion measurements see Intensive Erosion Measurements and Surveys, State-wide.
7. Plans for next year Instruments to be maintained and records collected on run-off, erosion, rainfall and vegetation. Analysis of vegetation quadrat data to be completed and report prepared.
8. Date of completion Indefinite.
9. Assignment Kraebel, Sinclair, Storey, Weaver.

January 1942

Relation of Woodland Cover to Streamflow
Kings River Branch - Big Creek Unit

1. Field division Forest and Range Influences.
2. Work project Influence of natural vegetation on streamflow.
3. Line project Woodland - relation of woodland cover to streamflow - Kings River Branch - Big Creek Unit.
4. Purpose To study precipitation, run-off, ground water, and erosion in relation to topography, geology, soil, vegetation and fauna in mountain areas by means of comparable small watersheds typical of the Sierra foothill region in the San Joaquin Valley.

To determine methods of managing watersheds in representative woodland forest type of oak, grass, chaparral and Digger pine in the Sierra foothills for maximum beneficial water yield, consistent with satisfactory control of floods and erosion and with other legitimate uses of the forest.

5. Review of past work Initiated 1934. Seven small watersheds (elevation range 1,000 to 2,000 feet) embracing 200 acres on tributaries of Big Creek which enters Kings River 45 miles from Fresno. Area grazed annually during April, May and June. Watersheds equipped with rain gages, standard and recording, climatic stations, streamgaging stations and reservoirs for measurement of erosion. Facilitating improvements include 5 miles of trails, 6 miles telephone lines, headquarters buildings and shop, and one field shelter house.

First records obtained in 1936, others started as installations were completed. Geologic study including map and report completed. A descriptive pamphlet, Technical Note No. 11, Kings River Branch Watershed Study Units, prepared by S. M. Munson.

Seasonal rainfall during past five years has varied from 16.98 to 42.48 inches with seasonal streamflow ranging from approximately 3 to 30 percent of the precipitation.

Data summarized and progress report prepared October 1940.

6. Accomplishments during past year Collection of precipitation, streamflow, erosion and climatic records continued. Data tabulated and compiled. Survey of rodent activity by Fish and Wildlife Service completed. Total precipitation for season 1940-41 35.66 inches at climatic station No. 2. Completed installation of streamgaging stations for study of spring flow.

7. Plans for next year Collection of records and tabulation and compilation of data dependent upon WPA assistance.
Analysis of data to be started if personnel permits.
8. Date of completion Indefinite.
9. Assignment Kraebel, Sinclair, with technical assistance of other staff members as required.

January 1942

Relation of Chaparral Cover to Streamflow
San Dimas Experimental Forest Run-off and Erosion Plots

1. Field division Forest and Range Influences.
2. Work project Influence of natural vegetation on streamflow.
3. Line project Chaparral - relation of chaparral cover to streamflow.
4. Purpose To study the influence of typical types of chaparral vegetation on surface run-off and erosion.
5. Review of past work
 - a. San Dimas series. Elevation 1200 feet, old north slope mixed chaparral, 2 pairs 1/40-acre plots established 1930. Vegetation on one pair undisturbed. Second pair burned annually until 1937, unburned since but continued as succession study. Run-off measurements discontinued.
 - b. Tanbark Flat series. Elevation 2800 feet, ceanothus-oak-chamise subtype unburned since 1919, 3 triplicate sets 1/40-acre plots established 1934. Vegetation on all plots undisturbed during calibration period. Run-off has averaged less than 1 percent of the rainfall with maximum of 2 percent during major storm of March 1938 with only trace of erosion.
 - c. Fern Canyon series. Elevation 5000 feet, oak-woodland subtype 50-year-old chaparral, 3 triplicate sets 1/40-acre plots established 1934. All plots denuded by forest fire November 1938. Plots treated immediately after fire as follows: 3 left untouched as controls; 3 oak stems felled and placed on ground surface along the contours; 3 sown to mustard. Natural vegetation has returned vigorously since fire. Maximum run-off before denudation less than 1 percent during storm of March 1938 with no erosion. First year following fire maximum run-off approximately 10 percent (seasonal average 5.27) of precipitation, with erosion up to 2000 cubic feet per acre. Second year seasonal run-off decreased to 1.16 percent and erosion to 145 cubic feet per acre. Oak stem felled along contours decreased run-off first year, no significant difference since.
6. Accomplishments during past year Measurements continued on all plots. No change in treatment. Run-off from Tanbark plots averaged 0.06 percent of rainfall and Fern plots 0.7 percent. Erosion from Tanbark series averaged 200 lbs. per acre and from Fern series 800 lbs. per acre, mostly due to creep or rodent activity and not water. Treatment of vegetation on Tanbark plots delayed pending initiation of interception studies now being started at this installation. Soil moisture sampling continued on Tanbark and Fern series, both in open areas and under brush canopies. All data tabulated and summarized through the 1940-41 hydrologic year.

7. Plans for next year Continue San Dimas series as a succession study only. Continue operation of Fern series under present treatments. Start treatment of vegetation on Tanbark series by silvicultural thinning 3 plots, clear cutting 3, and leaving 3 plots as controls. Control set of plots to have cut-off wall set at lower end in attempt to measure subsurface flow. Prepare manuscript with data from Fern plots.
8. Date of completion Definite date cannot be set for completion of project.
9. Assignment Kraebel, Sinclair, Rowe, Hamilton.

January 1942

Relation of Chaparral Cover to Streamflow
North Fork Run-off and Erosion Plots

1. Field division Forest and Range Influences.
2. Work project Influence of natural vegetation on streamflow.
3. Line project Chaparral - relation of chaparral cover to streamflow (woodland-chaparral brush in San Joaquin foothills). North Fork run-off and erosion plots.
4. Purpose To study influence of woodland-chaparral vegetation on water yield, surface run-off, and erosion.
5. Review of past work Installation comprises three pairs of 1/40-acre plots established 1929 and two pairs of 1/100-acre plots (with sprinkling apparatus) established 1933. Except for one year, 1930, the vegetation on one pair of 1/40-acre plots was burned annually from 1929 to 1938 and then allowed to return without further disturbance; on a second pair the vegetation was burned in 1930 and again in 1936; on a third pair the vegetation has been maintained without burning. The 1/100-acre plots were operated during a 3-year calibration period without disturbance of vegetation. Following the calibration period one pair of plots has been denuded annually by burning. A manuscript, "Influences of woodland-chaparral vegetation on soil-water relations," presenting results of first 9 years of the studies, submitted to Washington in March 1940 for publication as U.S.D.A. bulletin. Parts of the data also reported in numerous articles prepared by members of Forest Service and cooperating agencies. Most significant result since 1938 has been rapid decrease in surface run-off and erosion from annually burned plots since burning was discontinued in 1938. During period of annual burning surface run-off averaged over 14 percent of total precipitation and produced soil erosion at a rate of over 25,000 pounds per acre per year; whereas, during 1939-40, two seasons after last burn, surface run-off was less than 2 percent of precipitation, and erosion rate only about 75 pounds per acre.
6. Accomplishments
during past year Precipitation for 1940-41 season was 47.2 inches, approximately 14 inches above normal. Surface run-off from plots burned annually until 1938-39 season was 0.4 percent of total precipitation, from twice burned plots less than 0.2 percent of precipitation, and from undisturbed plots none. Erosion rates were 20.0 pounds per acre, 4.0 pounds per acre, and none, respectively.

On the pair of 1/100-acre plots burned annually since 1936, surface run-off was greater than 17 percent of precipitation and erosion at rate of approximately 7 tons per acre. On the pair with undisturbed vegetation cover there was no surface run-off and no erosion during

1940-41 season. Results of plot studies used in hydrologic analyses and in interpretation of hydrologic data by U.S.D.A. Flood Control Surveys in California. Partial results of studies reported in a paper, "Some factors of the hydrology of the Sierra Nevada foothills," by P. B. Rowe, Trans. Amer. Geophysical Union, Part 1, pp. 90-100, 1941. Parts of data also included in a manuscript, "The brush burning problems of California," prepared for publication as a State bulletin by Arthur W. Sampson, Professor of Range Management, College of Agriculture, University of California. Precipitation data published monthly by the Hydrometeorological Unit of U.S. Weather Bureau.

7. Plans for next year Reduction to minimum operating basis. Precipitation, run-off, and erosion measurements on all plots to be continued, if possible, without change in treatment. Labor permitting, natural rain on 1/100-acre plots will be supplemented by a series of runs employing artificial rainfall. Publication of parts of data planned for 1942.
8. Date of completion Indefinite.
9. Assignment Kraebel, Rowe.

January 1942

Relation of Chaparral Cover to Streamflow
Berkeley Run-off and Erosion Plots

1. Field division Forest and Range Influences.
2. Work project Influence of natural vegetation on streamflow.
3. Line project Chaparral - relation of chaparral cover (Coast brush type) to streamflow. Strawberry Canyon run-off and erosion plots at Berkeley.
4. Purpose To study the influence of chaparral vegetation on surface run-off and erosion.
5. Review of past work Installation comprises 3 pairs 1/60-acre plots established 1932. One pair maintained with natural vegetation cover, one pair burned periodically, one pair burned annually. Results to date indicate that reestablishment of vegetation in this type and climate is normally so rapid that repeated denudation only slightly increases surface run-off and erosion.
6. Accomplishments during past year Precipitation for 1940-41 season 44.27 inches. Surface run-off from annually burned, periodically burned, and undisturbed vegetation plots approximately 1.7 percent, 0.1 percent, and 0.1 percent of total precipitation, respectively. Erosion rates approximately 1.2 tons, 0.2 tons, and 0.01 tons per acre, respectively. Results used in connection with certain hydrologic analyses by U.S.D.A. Flood Control Surveys in California. Precipitation data published monthly by Hydrometeorological Unit of U. S. Weather Bureau.
7. Plans for next year Studies to be continued to observe long time effects of annual burning on surface run-off and erosion and to serve as demonstration unit for visiting scientists and forestry students only as long as WPA assistance available. Publication of results planned.
8. Date of completion Indefinite, dependent upon WPA continuance.
9. Assignment Kraebel, Rowe.

January 1942

Consumptive Use of Water by Chaparral Species
San Dimas Experimental Forest

1. Field division Forest and Range Influences.
2. Work project Water utilization by vegetation.
3. Line project Chaparral - consumptive use of water by chaparral species (lysimeter soil moisture, and interception studies).
4. Purpose To study influence of native chaparral vegetation on disposition of precipitation (percolation, transpiration, evaporation, interception, and run-off) under controlled conditions.
5. Review of past work San Dimas Lysimeters. Installation of five series completed 1937 and 1938 as follows: (1) 26 large concrete lysimeters, each 5 milacres in area, 6 feet deep, equipped to measure intensity of rainfall, run-off and percolation; (2) 5 unconfined units (soil blocks), each $17\frac{1}{2}$ feet square by 7 feet deep, equipped to measure surface run-off; (3) 5 root-study lysimeters 4 by 6 feet in area and 6 feet deep with removable wall for root excavation; (4) 30 medium-sized circular weighing type tanks, each holding 1800 lbs. of soil; and (5) 72 small circular weighing type holding 300 lbs. of soil each. All lysimeters filled with uniform soil, covered with excelsior mulch and exposed to natural rain for three seasons. Soil settlement measured annually and overfill removed from large, unconfined and root-study units in 1940. Soil added to small and medium tanks to replace settlement. All lysimeters sowed to Bromus mollis during fall 1940, excepting 1 large, 4 medium and 4 small units kept bare as controls. Soil moisture and volume weight explorations made during 1940 in large lysimeters 1, 2, 3, 6, 16, 22 and 23, and in unconfined blocks C and E. Periodic soil moisture sampling started in units 1, 22 and E. Data summarized and progress reports prepared on lysimeter performance.
6. Accomplishments Initial grass crop, Bromus mollis, reached maturity in June 1940 with excellent growth on large, unconfined and root-study lysimeters. Development on medium and small tanks and portions of border strips was poor. Roots of grass penetrated through full 6 feet of soil and into seepage compartments of large lysimeters. Average yields of Bromus mollis, in pounds of oven-dry material per square foot of surface area, for the several types of lysimeters, as follows: (1) large 0.069, (2) unconfined 0.084, (3) root-study 0.075, (4) medium 0.029, (5) small 0.013.

Summary of seasonal results comparing lysimeter #1 bare, #2 to 26 inclusive, with grass cover and unconfined units A to E inclusive, also with grass cover, is given in following table:

Average lysimeter performance

Season 1940-41

(Amounts in surface inches)

Lysim- No.	Precipi- tation P	Run-off R	Seepage S	Water yield R + S	Infil- tration P - R	Retention P-(R+S)
1	46.85	37.02	0.64	37.66	9.83	9.19
2-26	47.10 <u>1/</u>	36.54	0.04	36.58	10.56	10.52
A-E	39.89 <u>2/</u>	30.84	2.00 <u>3/</u>	32.84	9.05	7.05
Percent of rainfall						
1		79.0	1.4	80.4	21.0	19.6
2-26		77.6	0.1	77.7	22.4	22.3
A-E		77.3	5.0	82.3	22.7	17.7

1/ Includes watering of grass.2/ For part of season only3/ Calculated from soil moisture samples.

Continued high amounts of surface run-off and low seepage under grass cover may be due to lack of normal structure in the lysimeter soil.

Comparative results of evaporation from bare soil and evapo-transpiration loss through grass cover determined from seepage and run-off records supplemented by soil moisture sampling as follows:

	Surface inches water in 6 ft. soil depth	Total for period October 1940- August 1941 (surface inches)
	October 1940:August 1941:	Precip.:Run-off:Seepage:Evapo-trans.
#1 bare	19.0 19.4	: 46.8 37.0 0.6 8.8 <u>1/</u>
#22 grass	20.1 15.2	: 47.1 36.7 0.0 15.4

1/ Evaporation only.

Data indicate that presence of grass resulted in loss of about 6 inches more water than was lost from bare soil. This must be qualified by luxuriant growth of grass that had abundant soil moisture available during its entire growing season.

All data summarized to date. Plan for analysis of lysimeter data prepared and manuscript completed entitled "A lysimeter study of Bromus mollis."

7. Plans for next year Continue cover of Bromus mollis. Start experimental plantings in border area of species proposed for use in lysimeters. Continue soil moisture sampling program more intensively, supplemented by tensiometer installation. Complete analyses of data to determine comparative relationships between types of lysimeters.
8. Date of completion Indefinite.
9. Assignment Kraebel, Sinclair, Rowe, Hamilton, Colman.

January 1942

Consumptive Use of Water by Chaparral Species
Berkeley

1. Field division Forest and Range Influences.
2. Work project Water utilization by vegetation.
3. Line project Chaparral - consumptive use of water by chaparral species (Berkeley lysimeters, Oxford Street and Strawberry Canyon).
4. Purpose To study influence of brush and chaparral vegetation, including mustard cover and various types of forest litter, on disposition of precipitation (interception, infiltration, evaporation, transpiration, percolation, and surface run-off).
5. Review of past work Oxford Lysimeters. Initiated 1927 with series A of eight lysimeters. Two series, B and C, of five tanks each, added 1931. Series A and C discontinued 1936. Soil in series B tanks resurfaced July 1933 and sown to Bromus mollis to establish root penetration in upper soil surfaces. In November 1934 grass burned off and Monterey pine litter to depths of $1\frac{1}{4}$ -inch, $3/4$ -inch, $1/2$ -inch, and $1/4$ -inch placed on soil surfaces in tanks 1, 2, 3, and 4, respectively. May 15, 1940, litter cover burned off all tanks and all tanks except #1 planted to black mustard, Brassica nigra. Publications: "Influence of forest litter on run-off, percolation, and erosion," Jour. Forestry, April 1930. "Run-off and erosion experiments in mountain areas," Station mimeographed pamphlet 1935. Partial results also used in other publications.

Strawberry Canyon Lysimeters. Two series (A and B) each of five rectangular lysimeters installed 1931. Individual lysimeters are 80 square feet in area by 50 inches deep. Three tanks of series A filled with Altamount soil collected at site of installation and two filled with Sierra foothill sandy clay loam collected near North Fork. Series A tanks planted to Quercus dumosa in 1933. All five tanks of series B filled with Altamount soil. Planted to Ceanothus cuneatus in 1933. All tanks (Series A and B) operated without treatment until June 1938 to allow vegetation to form complete canopy. In 1938 thinnings of vegetation were started on series B, as follows: Tank 1, vegetation undisturbed, density 60 percent; tank 2, density of vegetation reduced to 51 percent; tank 3, to 41 percent; tank 4, to 19 percent; and tank 5, completely denuded. Density of vegetation on series A not yet sufficient to permit satisfactory manipulation. Prior to treatment evaporation-transpiration losses for series B were approximately 3 to 4 inches greater and total percolation from 3 to 4 inches less than for series A.

6. Accomplishments during past year Oxford Lysimeters. Installation B dismantled in September 1941. Photographs and descriptions of soil profiles obtained and soil samples collected. During 1940-41 rainy season there were 37.15 inches of rainfall. Surface run-off, percolation and evaporation from mustard-cover tanks averaged approximately 5, 65, and 30 percent respectively, of total precipitation; from the bare soil tanks 43, 31, and 26 percent. The evaporation losses are for the rainy season (October 1 to May 30) only. Erosion from the bared soil tank was over 20 times greater than from the mustard-covered tanks.

Strawberry Canyon Lysimeters. Rainfall for the oak lysimeters, series A, for 1940-41, was 44.25 inches. Average surface run-off, percolation, and evaporation-transpiration-interception from Altamount soil tanks was approximately 0, 52, and 48 percent, respectively, of total precipitation; and from Sierra soil tanks 1, 57, and 42 percent. Rainfall, surface run-off, evaporation, and percolation for 1940-41 season for installation B is given in following table:

	: Tank #1	: Tank #2	: Tank #3	: Tank #4	: Tank #5
	: Density	: Density	: Density	: Density	:
	: of cover	: of cover	: of cover	: of cover	: Bare
Factors recorded :	60%	: 51%	: 41%	: 19%	: soil
			Inches depth		
Rainfall	44.80	44.80	44.80	44.80	44.80
Surface run-off	0.01	0.41	0.02	0.63	2.03
Percolation	19.08	19.74	20.63	23.83	30.42
Total evaporation	25.71	24.65	24.15	20.34	12.35
			Pounds - oven-dry		
Erosion	Trace	Trace	0.6	3.0	3.3

7. Plans for next year Oxford Lysimeters. Discontinued indefinitely. Publications planned.

Strawberry Canyon Lysimeters. Installations to be continued, if possible, until distribution of soil moisture in tanks can be determined. Progress report planned.

8. Date of completion Two to five years.
9. Assignment Kraebel, Rowe.

January 1942

Consumptive Use of Water by Chaparral Species
North Fork

1. Field division Forest and Range Influences.
2. Work project Water utilization by vegetation.
3. Line project Chaparral - consumptive use of water by chaparral species (lysimeter, soil moisture, and interception studies).
4. Purpose To study influence of woodland-chaparral vegetation on disposition of precipitation as surface run-off, interception, evaporation, transpiration and percolation.
5. Review of past work Lysimeters. Four small rectangular lysimeters installed in 1932 and filled with soil collected at site of installation. From 1932 to 1937 two tanks, 13 and 15, maintained with bare soil surfaces and two tanks, 12 and 14, with a 2-inch ponderosa pine litter cover. In 1937 litter cover burned off tank 14, a 2-inch ponderosa pine litter placed on tank 15, and tanks 12 and 13 continued in operation without change in treatment. In all cases the litter cover completely prevented erosion and caused great reduction of surface run-off and evaporation and an increase of percolation. In September 1940 litter cover burned on tank 15 and tanks 14 and 15 sowed to annual grass (Bromus mollis).

Four small circular lysimeters installed in 1932 and filled with soil collected at site of installation. All tanks operated with bared soil surfaces until 1937. Annual evaporation losses during this period averaged from 12 to 13 inches. In March 1937 all tanks planted to Bromus mollis. In September 1937 two tanks bared by burning and kept bare continuously to date. Annual evaporation losses from grass covered tanks averages from 4 to 6 inches more than from bare soil tanks.

Soil moisture studies. Two 1/200-acre soil moisture sampling plots established July 1934, a third established July 1936. One plot maintained with undisturbed vegetation, one burned off annually, one completely denuded. Annually burned and denuded plots trenched to isolate soil block from root penetration of surrounding vegetation. Soil moisture samples collected by 3-inch increments to 48-inch depth before and after each storm and at intervening intervals of ten days. Moisture percent and moisture equivalent determinations made for each sample. Average annual evaporation (interception, transpiration, and evaporation) from undisturbed plot about 19 inches, from plot burned annually but with regrowth permitted between burns about 17.5 inches, and from continuously denuded plot about 12.5 inches depth per year. Soil moisture sampling discontinued in September 1940.

Interception studies. First installation, in 1937, included 16 slope rain gages and about 30 stemflow units, was discontinued in July 1940. Second installation established July 1940 to obtain data under both natural and artificial rainfall in connection with 1/100-acre plot studies. This will yield data on both volumes and rates of precipitation, interception, stemflow, and interception losses from an undisturbed brush cover. Total interception averaged about 20 percent, stemflow about 15 percent, and interception loss (total interception less stemflow) about 5 percent of annual precipitation. Interception losses due to evaporation during periods of actual rainfall are very small.

Results of the studies to 1938 included in manuscript submitted for publication as U.S.D.A. bulletin. Parts of the data have also been reported in articles by members of the Forest Service and cooperating agencies.

6. Accomplishments during past year Lysimeters. During 1940-41 there were 48.11 inches of precipitation at the rectangular lysimeter installation. From tank 12 (2-inch depth ponderosa pine litter cover, 1932 to date) there were 1.4 inches surface run-off, 39.8 inches percolation, and 7.0 inches evaporation. From tank 13 (bare soil 1932 to date) there were 26.0 inches surface run-off, 8.3 inches percolation, and 13.8 inches evaporation. From tank 14 (2 inches litter cover 1932-37, bare soil 1937-40, annual grass cover 1940 to date) 30.0 inches surface run-off, 6.2 inches percolation and 11.9 inches evaporation. From tank 15 (bare soil 1932-37, 2 inches litter cover 1937-40, annual grass cover 1940 to date) there were 24.6 inches surface run-off, 11.3 inches percolation, and 12.2 inches evaporation.

The results for the circular lysimeters and interception studies for the 1940-41 season were not significantly different from those of previous years.

Results of the North Fork water utilization studies have been used in hydrologic analyses and the interpretation of hydrologic data by the U.S.D.A. Flood Control Surveys in California. Partial results of the studies were reported in a paper, "Some factors of the hydrology of the Sierra Nevada foothills," Transactions American Geophysical Union, Part 1, pages 90-100, 1941. Parts of the data also included in a manuscript on brush burning by Arthur W. Sampson, Professor of Range Management, College of Agriculture, University of California.

7. Plans for next year All active installations to be continued in operation during the next rain season. Publication of results of interception-stemflow studies and of lysimeter litter studies planned.
8. Date of completion Indefinite.
9. Assignment Kraebel, Rowe.

January 1942

Consumptive Use of Water by Forest Cover
Bass Lake

1. Field division Forest and Range Influences.
2. Work project Water utilization by vegetation.
3. Line project Forest cover - consumptive use of water by forest cover (second growth ponderosa pine) Bass Lake.
4. Purpose To study the influences of second-growth ponderosa pine cover on disposition of precipitation (surface run-off, interception, evaporation, transpiration, and percolation).
5. Review of past work Soil moisture studies. Three 1/40-acre soil moisture sampling areas established September 1940. Vegetation on one area undisturbed, herbaceous vegetation and litter cover on one area burned off annually and one area maintained completely free of all vegetation. Denuded area trenched and enclosed with galvanized iron walls to a depth of 72 inches to isolate soil block from root penetration of surrounding vegetation. Since October 1940 soil moisture samples collected from each area by 3-inch increments at intervals of 10 days and just before and immediately after each storm. Moisture percent and moisture equivalent determinations made of each sample collected. Samples for volume weight and organic content determinations and for chemical and physical analyses also collected periodically.

Interception studies. Installation established in September 1940 in second-growth 60- to 80-year-old ponderosa pine stand. Includes 3 open rain gages, 4 open tree crown gages, 20 interception gages, 32 stemflow units, 20 snow pans, and a snow course.
6. Accomplishments during past year Soil moisture studies. Soil moisture sampling schedule maintained and laboratory analyses kept up to date.

Interception studies. Data for 1940-41 season tabulated and analyses in progress. Interception losses averaged approximately 16 percent of precipitation. Interception study to determine evaporation losses from different depths of ponderosa pine litter started in September 1941.
7. Plans for next year Studies now in progress to be continued if personnel permits. Interception installation to be equipped if possible to provide for the recording of intensity measurements of interception losses.
8. Date of completion Indefinite.
9. Assignment Kraebel, Rowe.

January 1942

Consumptive Use of Water by Riparian Vegetation
"Y" Canyon

1. Field division Forest and Range Influences.
2. Work project Water utilization by vegetation.
3. Line project Tree species - transpiration and other consumptive uses of water by riparian vegetation in southern California.
4. Purpose To measure losses in water yield from a mountain watershed occasioned by transpiration of riparian vegetation.
5. Review of past work. Initiated in 1931 in cooperation with U.S. Bureau of Agricultural Engineering. Four streamgaging stations constructed and detailed surveys of canyon-bottom vegetation and geology made. Development of underground leak to adjacent canyon resulted in abandoning lowest gaging stations. Paper presented at A.A.A.S. meeting in Berkeley, 1933, entitled "Vegetation of a southern California canyon." Joint progress report prepared in 1934 and summary report in 1938. Flood in March 1938, caused by 18-inch rain, completely cleared "A" fork of the "Y" and the main channel below the fork of all streambottom vegetation. "B" fork was comparatively unaltered. Weir reinstalled at mouth of "A" fork and in lower main channel to compare bare and vegetated streambottoms. One climatic station installed in clear area of main channel and one under cover in "B" fork. Records collected during summer months only. Data obtained since first report partially analyzed.
6. Accomplishments during past year Instruments installed and data collected during summer months tabulated. Instruments removed for winter season.
7. Plans for next year Reinstall instruments and collect records for summer period if personnel available. If not, measurements will be discontinued for two or three years then resumed for a like period, etc., to obtain at least intermittent data during regrowth of riparian trees. Continue compilation and summarization of data.
8. Date of completion Indefinite.
9. Assignment Kraebel, Sinclair, Storey, Weaver.

Influence of Various Physiographic, Climatic, and
Biotic Factors on Infiltration

1. Field division Forest and Range Influences.
2. Work project Streamflow - relation of vegetation cover to streamflow, state-wide infiltration capacity measurements.
3. Line project Infiltration. Influence of various physiographic, climatic, and biotic factors on infiltration.
4. Purpose (1) To test further and perfect North Fork infiltrometer and other infiltration equipment and to develop methods for analysis and interpretation of infiltration data. (2) To determine influence of such factors as slope, soil type, vegetation, land use, and intensity and duration of rainfall on infiltration capacity of soils. (3) To develop use of infiltration data in hydrologic analyses of watersheds as a means of determining benefits of various land use and cover changes for control of floods and conservation of water and soil.
5. Review of past work Instrumentation, operating procedures, and methods for analysis and interpretation of infiltration data developed and tested under field conditions. "The construction, operation, and use of the North Fork infiltrometer," CF&RES Misc. Publication No. 1. Infiltration studies and surveys completed include: (1) Kennett study, 15 runs, with Auten tube, to determine effect of denudation of forest cover by smelter fumes on infiltration capacity of soil. "An infiltration study of a denuded and a forest-covered soil." CF&RES Research Note No. 14. (2) Friant study, 130 runs with North Fork infiltrometer, to test instrumentation and determine application of infiltration data to hydrological analyses. Data used also by Bur. of Reclamation in estimating drainage construction needed to protect canals from Friant Reservoir against flood damage. (3) San Joaquin Experimental Range study, 54 runs with North Fork infiltrometer, to determine influence of different intensities of grazing on infiltration capacity of soil. Results reported in bi-monthly reports and used in hydrologic analyses by Flood Control Surveys. (4) U.S.D.A. Flood Control infiltration surveys in California: Pajaro drainage, 220 runs with North Fork infiltrometer; Santa Maria River drainage, 255 runs with North Fork, F, and FA types of infiltrometers; Santa Ynez River drainage, 38 runs with FA infiltrometer. In Flood Control infiltration surveys, Rowe acted as technical consultant and assisted in interpretation and analyses of data.

Results of infiltration work in California have shown very large differences in infiltration capacities of different vegetation and soil types. In general cultivated and grass (grazing) lands have much lower infiltration capacities than brush and forest lands; destruction

or depletion of natural vegetation by fire, over-grazing or other misuse have without exception resulted in soil deterioration and reduced infiltration capacities and consequently have caused increased flood and erosion hazards.

6. Accomplishments during past year New procedure of hydrologic analysis, employing infiltration capacity measurements and other watercycle data developed by the Station, for use on flood control surveys in determining quantitative effects of various land use practices in flood control and soil and water conservation. This method, eliminating use of constants, accepted by all agencies connected with U.S.D.A. Flood Control Surveys in California.

This procedure examines and evaluates individually the influence of all on-site factors of a watershed complex affecting streamflow, such as vegetation cover, topography, and soil characteristics. It also shows to what extent a given remedial treatment of a flood source area will affect run-off and other water relations. This method used in Russian River Preliminary Examination and Santa Maria Flood Control Survey.

7. Plans for next year Infiltration studies now in progress to be continued and additional studies to be undertaken as time and facilities permit. Publication of hydrological analysis procedure and of various infiltration data collected to date is planned.
8. Date of completion Indefinite.
9. Assignment Kraebel, Rowe, and other members of the Influences staff.

January 1942

Relation of Forest, Brush, and Grassland Cover and
Management Practices to Erosion and Soil Stability
State-wide

1. Field division Forest and Range Influences.
2. Work project Stabilization of soils.
3. Line project Watersheds - relation of forest, brush, and grass-
land cover and management practices to erosion
and soil stability and to quality and usability of water (intensive-
measurement erosion surveys).
4. Purpose To determine amount of erosion from mountain areas
in relation to precipitation, vegetation, geology,
soil, and other contributing factors by surveys of sedimentation in
reservoirs commanding large and small watersheds and by detailed measure-
ments from plots.
5. Review of past work Measurements of erosion from drainage units
started in 1927 at Barranca watershed (Devil Canyon
Branch), later extended to Lost Creek Reservoir (Plumas National Forest);
Bell, Fern, San Dimas, and Big Dalton watersheds (San Dimas Experimental
Forest); Big Creek and Teakettle Creek watersheds (Kings River Branch).
In cooperation with the Soil Conservation Service, deposits in the
Morena and Little Rock Reservoirs in southern California were surveyed
and the results published in a joint report as USDA Tech. Bull. 639
(1939).

Erosion from plots on the San Dimas Experimental Forest has been re-
ported elsewhere under "RI STREAMFLOW, Shrub Cover - relation of
chaparral cover to streamflow, San Dimas Experimental Forest". Other
erosion plot studies have been made on burned watersheds in southern
California and in the smelter-fume denuded area near Kennett, in
northern California.

Summarized data for most of the watersheds and plots appear in the
Annual Report for 1940 (January 1941).

6. Accomplishments Sedimentation in the Barranca, Big Dalton, and San
during past year Dimas reservoirs surveyed. Erosion from all San
Dimas Experimental Forest plots measured (see
project sheet referred to above). Following table shows erosion rates
obtained this year from Bell and Fern watersheds of San Dimas area.
Extremely high erosion in Fern No. 2, from 5 to 19 times as great as
that in the other watersheds, is accounted for by action of stream
in cutting through a land-slump containing some 200 cubic yards of
material deposited in channel during 1938 flood.

<u>Watershed</u>	<u>Eroded material cubic yard</u>	<u>Erosion rate cubic yard/ square mile</u>
Bell 1	3.5	29
2	3.5	22
3	7.5	77
4	Trace	Trace
Fern 1	3.1	56
2	27.2	432
3	2.0	24

7. Plans for next year Detailed surveys of silt deposits in San Dimas and Big Dalton Reservoirs will be made if seasonal deposition is significant. Erosion records from all plots will be continued.
8. Date of completion Indefinite.
9. Assignment Kraebel, Sinclair, Rowe, Storey, Hamilton.

January 1942

Revegetation for Watershed Improvement

1. Field division Forest and Range Influences.
2. Work project Stabilization of soils.
3. Line project Watersheds - propagation and testing of plants for watershed improvement.
4. Purpose Development of satisfactory planting practices for watershed improvement in California, with emphasis on optimum methods of obtaining and processing seed, germinating, propagating, and growing chaparral, broadleaf and coniferous species and their evaluation for erosion control on burned areas, road slopes, slides and other sites needing cover improvement.
5. Review of past work Seed handling. The results of this project, which was initiated in 1931 and expanded in 1934, have been summarized in (a) 1937 CCC Forestry Publication No. 5, "Collecting and handling the seeds of wild plants" by N. T. Mirov and C.J. Kraebel; and (b) 1940 Research Note No. 21, "Additional data on collecting and propagating the seeds of California wild plants " by N. T. Mirov.

Nursery practice and propagation. Two experimental plant nurseries established. The first in 1927 at Devil Canyon on San Bernardino National Forest with financial aid from several southern California counties, the second in 1936 at Berkeley in cooperation with the University of California and Region 5. All stock surplus to actual research needs is distributed to cooperating agencies. Berkeley nursery is operated with WPA labor and part-time technical supervision by our former nursery superintendent contributed by the East Bay Regional Park, his present employer.

Devil Canyon Nursery has an average annual production of 38,000 plants of which 30,000 have been distributed to southern counties and national forests for erosion control and improvement planting. Berkeley nursery has distributed approximately 30,000 plants per year for similar use in the national forests of the State and the East Bay Regional Park.

Research projects at both nurseries include studies of seed storage, germination, vegetative propagation, potting methods and general nursery practice for many promising shrub and sub-shrub species for which cultural techniques are unknown.

Planting and sowing. Approximately 38,000 trees and shrubs have been planted experimentally in burns and other areas of depleted forest cover along roadsides and on slope fixation projects. In cooperative similar tests, upwards of 100,000 plants from our nurseries have been set out to date, many of them in Cleveland National Forest by San Diego County Road Department, and in East Bay Regional

Park, Berkeley. Six plots were established in 1935 and 1936 on San Dimas Experimental Forest at elevations ranging from 1500 to 5000 feet to test effectiveness of succulent species for fire-resistant ground cover planting on firebreaks. Additional plots established on Los Padres National Forest. A freeze in 1937 killed most of the plants at San Dimas but not those on Los Padres National Forest.

Demonstration of the successful sowing of mustard (Brassica nigra) for erosion control of burned watersheds has resulted in its acceptance as a standard first-aid treatment of recent burns by the Forest Service and other forest agencies. After Fern Canyon fire of Nov. 1938, watershed No. 1 was sown to mustard. Survey begun and plots established to determine effectiveness of cover, relation of climate to subsequent years' crops and effect of mustard cover on natural succession.

6. Accomplishments during past year Nursery practice and propagation. Distribution of 26,000 plants from Berkeley and 42,000 from Devil Canyon Nursery for erosion control and improvement plantings by national forests and other agencies. Emphasis shifted at Devil Canyon from production of coniferous stock to production of native California shrubs.

Planting and sowing. Shrub plantings on San Dimas Experimental Forest showed that shrubby species of Rhus, Adenostoma, Prunus ilicifolia, Ericameria parishii and pinifolia, Robinia neomexicana, Diplacus longiflorus, and species of Salvia would give excellent survival when potted stock used. Browsing by deer and competition from other plants caused majority of failures. Plantings of native shrubs established on slides and on other areas needing cover improvement in Arroyo Seco to evaluate their effectiveness.

Survey and plots for study of mustard effectiveness continued in Fern Watershed No. 2. Analysis awaits another year's records.

7. Plans for next year Nursery practice and propagation. Continue propagation of erosion control plants for experimental use with emphasis upon native shrubs suitable for southern California flood control program.

Planting and sowing. Continue plantings for cover improvement on slides and other areas. Examine past plantings and bring analysis to date. Continue for another year tests of effectiveness of mustard in erosion control and studies of phenology and succession of mustard in Fern watershed No. 1. Analyze these records for possible publication.

8. Date of completion For project as whole: intensive investigation to be completed in next five years. Routine examinations and observations to continue beyond this period.

9. Assignment Kraebel, Sinclair, Weaver.

January 1942

Development of Methods and
Stabilizing of Earth Fills and Cuts
Mountain Roads

1. Field division Forest and Range Influences.
2. Work project Stabilization of soils.
3. Line project Roads - development of practicable and inexpensive methods of permanently stabilizing unconsolidated earth fills and cuts, particularly in connection with mountain road construction.
4. Purpose Development of economic methods of preventing or controlling destructive erosion on mountain roads by improved drainage practices, slope fixation and planting.
5. Review of past work Contour method of brush wattling which has proved satisfactory on road fills is outlined in detail in U.S.D.A. Circular 380, "Erosion control on mountain roads", published in March 1936. Thirteen hundred shrubs representing 28 species were planted at various elevations to test their adaptability for erosion control purposes. Plants surplus to our needs were supplied to San Diego County Road Department for test planting on mountain roads in that county and to the East Bay Regional Park, Berkeley, for same purpose.
6. Accomplishments during past year Plantings examined and results analyzed. The successful species are listed under "RI, SOIL STABILIZATION, Watersheds - Revegetation for watershed improvement."
7. Plans for next year Repeat examinations of experimental plantings. Examine 1934 road erosion control treatments on San Dimas Experimental Forest to determine plant succession in these areas.
8. Date of completion Indefinite.
9. Assignment Kraebel, Sinclair.
Cooperators: Mr. G. Juhren, San Diego County Road Department; J. B. Roof, East Bay Regional Park, Berkeley.

January 1942

Effect of Vegetation on Local Climate
(State-wide project)

1. Field division Forest and Range Influences.
2. Work project Effect of cover on climate.
3. Line project Vegetation: effect of forest, chaparral and grass covers on local climate.
4. Purpose To study the micro-climate of different vegetation types as influenced by cover, geographic location, topography, altitude, and soil.
5. Review of past work Climatic studies were initiated in 1926 with the beginning of forest influences work in the Region. They include all precipitation, air, snow and soil temperature, relative humidity, air movement, and evaporation studies conducted at the field stations within the chaparral region, and are collected primarily for use in conjunction with other forest influences data. A list of the principal work centers and the observations now recorded at each are given in the following table:

Work center	Year	Climatic factors observed and number of installations								Complete climatic station
		:Pre- :record :started	:Hu- :cipi- :tation	:Air :temp. :ity	:Hu- :mid- :ity	:Evapo- :ration	:Air :move- :ment	:Soil :temp. :course	:Snow :course	
Devil Canyon	1926	10	1	1	1	1	2	-	1	
North Fork	1929	10	1	1	1	1	2	3	1	
Berkeley 1/	1931	9	2	2	4	2	-	-	2	
San Dimas	1932	340	7	7	6	6	8	-	4	
Bass Lake	1934	9 2/	1	1	-	2	-	3 3/	1	
Kings River										
Big Creek	1935	103	3	3	1	4	1	-	-	
Teakettle Crk.	1938	1	1	1	-	1	1	15 4/	-	

1/ Strawberry Canyon and Oxford Street stations, the latter discontinued in 1941.

2/ Includes 4 elevated tree crown gages.

3/ Also 4 snow-melting stations.

4/ Also 1 snow-soil temperature station.

Devil Canyon, North Fork, Berkeley and San Dimas installations are in chaparral types, Bass Lake is in second growth ponderosa pine, Big Creek in woodland-grass, and Teakettle Creek is in a fir-pine forest. In addition to the above, other precipitation, temperature and humidity records have been collected in connection with several smaller influences studies.

6. Accomplishments
during past year

All stations maintained and data tabulated for season. An additional elevated gage established among tree crowns at Bass Lake.

San Dimas Forest. Exposure of two anemometers at Johnstone Peak fire lookout indicated that instrument at tower showed a considerable deficit in free air movement as compared to one located with a view to accuracy of record rather than convenience in reading. Climatic records tabulated and summarized to date. Eight-year air temperature means and departures therefrom in course of preparation as shown in table below.

Summary of air temperature monthly means by stations for 1940-41 season
and term means for period since establishment of station

	: San Dimas:		Tanbark:			: San Gab-:		Fern 1/:		Fern #1 1/2:	
	: Canyon :		Flat :		Bell #2:	Bell #4:		riel Div.:		5100' : 5200'	
	1940-41	1940-41	8-yr. mean	1940-41	8-yr. mean	1940-41	8-yr. mean	1940-41	8-yr. mean	1940-41	8-yr. mean
October	67	65	61	68	65	68	65	66	63	62	60
November	56	54	55	56	59	57	60	52	54	50	53
December	56	54	51	57	56	58	56	52	51	51	49
January	50	47	46	50	48	48	48	44	47	43	43
February	52	50	47	51	48	50	48	45	46	44	43
March	52	51	50	53	52	52	51	46	50	45	47
April	52	50	53	51	55	50	55	46	54	45	51
May	64	61	58	61	59	62	60	61	60	59	58
June	63	60	62	62	64	62	64	72	67	61	64
July	73	72	71	74	73	79	76	77	75	72	73
August	70	68	72	71	74	71	75	71	75	68	74
September	66	63	68	69	71	67	72	66	71	63	68
Annual	60	58	58	60	60	60	61	57	59	55	57

1/ Term mean not completed.

7. Plans for next year Continue existing stations and records. Establish temporary air temperature station in watershed X (Monroe Canyon) if possible, to determine if existing stations give representative values in southwest corner of San Dimas Forest.

8. Date of completion Indefinite.

9. Assignment Kraebel and Forest Influences staff as a whole.

January 1942

Flood Control Investigations
Cooperation in and Review of other Bureau Reports

1. Field division Flood Control Investigations.
2. Work project Flood Control Surveys.
3. Line project Cooperation with other government agencies engaged in flood control investigations and review of flood control reports by such agencies.
4. Purpose To cooperate with Soil Conservation Service and Bureau of Agricultural Economics by exchange of personnel on detail basis for flood control investigations; to cooperate with these bureaus and U.S. Engineer Department by exchange of data and in other ways essential in flood control investigations; to review preliminary examination reports of the BAE and survey reports of the SCS on streams within California region.
5. Review of past work Prior to March 15, 1941 all flood control investigations were conducted and reports prepared in direct cooperation by representatives of Forest Service, SCS and BAE under chairmanship of either FS or SCS. Under that organization Los Angeles River survey report was completed, San Gabriel nearly completed and Santa Ana started under FS leadership. Numerous preliminary examination reports were completed under same arrangement.
6. Accomplishments during past year Preliminary examination report on Russian River nearly completed before its transfer to BAE. Station cooperation (part-time of Rowe) on hydrological aspects of this report showed possible reduction of 22 percent in peak flow by application of remedial measures. Several FS technicians were on detail to SCS on Santa Ana Survey until August 1941, and three have been on indefinite detail to BAE on Preliminary Examinations since October 1941.

Preliminary examination report on Santa Monica Mountains group of watersheds reviewed. Several Army reports reviewed. Participated in several meetings of Flood Control Advisory Committee for California.
7. Plans for next year Continue cooperation and reviews as required so long as funds available.
8. Date of completion Indefinite.
9. Assignment Talbot, member of Flood Control Advisory Committee; Kraebel; Ilch, Bomberger (on detail to BAE for Preliminary Examinations).

January 1942

Watershed Surveys

1. Field division Flood Control Investigations.
2. Work project Flood control Surveys.
3. Line project Watershed surveys (detailed surveys).
4. Purpose To determine flood and erosion source areas and to develop economically feasible measures for control of erosion and retardation of run-off.
5. Review of past work Under authority of the Flood Control Act of June 22, 1936, and subsequent Amendments of 1937, 1938, 1939 and 1941 the Department of Agriculture began detailed surveys on following California watersheds: Los Angeles, 1938; San Gabriel, 1939; Pajaro, 1940; Santa Ana, 1940, Santa Maria, 1940; and Santa Ynez, 1941. The Forest Service, Soil Conservation Service, and Bureau of Agricultural Economics cooperated in the field surveys and preparation of reports up to March 15, 1941. Since then responsibility for detailed examinations has been assigned to individual bureaus. Under this policy the San Gabriel, Santa Maria and Santa Ynez watershed surveys were made responsibility of Forest Service.
6. Accomplishments during past year Survey work plans for Santa Ynez Survey completed and approved, and survey work begun in September. Status of surveys is as follows: San Gabriel 99 percent complete; Santa Maria 98 percent; Santa Ynez 33 percent. Several Forest Service technicians were on detail to the Santa Ana Survey under SCS leadership until July 1941. A sedimentation survey of Gibraltar Reservoir in upper Santa Ynez River basin made in October. This reservoir is the water supply for Santa Barbara and neighboring towns. Plots were established in all major cover types and conditions of land use to determine by field test infiltration capacities of different sites.

The operations programs authorized for portions of the Arroyo Seco watershed and the San Fernando Valley, tributaries to Los Angeles River, were begun by Forest Service and Soil Conservation Service, respectively, as action agencies. Initiated cooperative laboratory project between Regional Office, University of California, and Experiment Station on model study of flood and erosion control structures for mountain channels for Los Angeles River flood control project, involving reproduction in model form of Arroyo Seco channel from Oak Wilde to canyon mouth on a scale of one to fifty.
7. Plans for next year Review and completion of survey reports for San Gabriel, and Santa Maria watersheds. Completion of field work and preparation of survey report for Santa Ynez watershed.

Initiation of new surveys for other watersheds when approved.
National defense activities have developed to such an extent in certain watersheds that it has brought about a change in priority ratings and a new urgency for intensive survey information.

8. Date of completion San Gabriel and Santa Maria early in 1942
and Santa Ynez about September 30, 1942.

9. Assignment Kraebel, Kolbe, Gleason, Sykes, and flood
control staff, including technicians on detail from SCS and BAE.